THE UNIVERSITY OF TEXAS BULLETIN
No. 3019: May 15, 1930

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By Helen Jeanne Plummer

FORAMINIFERA OF THE CISCO GROUP OF TEXAS

By

J. A. Cushman and J. A. Waters

Bureau of Economic Geology

J. A. Udden, Director E. H. Sellards, Associate Director

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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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CALCAREOUS FORAMINIFERA IN THE BROWNWOOD SHALE NEAR BRIDGEPORT, TEXAS

By HELEN JEANNE PLUMMER

INTRODUCTION

In the north edge of Bridgeport, Wise County, Texas, the Bridgeport Brick Company has excavated extensively into an outcrop of fossiliferous, somewhat gypsiferous, compact, grey, and variegated shale. These beds are regarded as the lower portion of the Brownwood shale[1] (Graford formation) below the Willow Point limestone. The most fossiliferous outcrops comprise the immediate slopes on the west side of the northernmost excavation, now abandoned and partly filled with water. It is from this 25- to 30-foot exposure of shale, capped by a conspicuous, westward-dipping, 2-inch, white sandstone, that an extensive collection of fossils has been made. Of this varied fauna the calcareous foraminifera have proved especially interesting in their relationship to the lithology of these strata and to the other members of this group of forms.

Throughout about 25 feet of section above the water level in the abandoned pit the pure shale is very compact and tough and carries almost no trace of siliceous minerals. Limonite flakes, partings, and small nodules are common on the weathered surface of the beds, and in places gypsum crystals abound. The lower 10 feet consisting of very dark shales change rapidly upward into variegated purple, purplish-red, and yellow shales that weather into flaggy nodular masses or thin papery laminae.

Fossils are sparsely scattered over all the slopes of this heavy shale section, but they are much more abundant and varied in the lower 8 or 10 feet and are almost absent in the upper 10 feet. Samples were collected for micro-fossils

[1]Correlation made by J. M. Armstrong and F. B. Plummer and so published on the Wise County geologic map issued by the Cooperative Mapping Committee Bureau of Economic Geology.

Printed October, 1930.

at close stratigraphic intervals up to the first white sandstone layer, and all concentrates studied were rich in minute organisms. The fauna is, however, somewhat more varied in the lower 15 feet. The upper variegated shales are especially rich in brilliantly stained arenaceous tests and carry calcareous forms in less abundance.

The fresh, dark clay is so tough, that slow drying in a warm oven is necessary before it can be readily disintegrated in water. After washing away the bulk of the argillaceous material, the final reduction is facilitated by boiling the soft clay in a strong solution of sodium carbonate (sal soda), a process that breaks down quickly the binding colloid and releases immediately and completely all the heavy residue. A small clean concentrate rich in well-developed tests of *Ammodiscus incertus* (d'Orbigny) and of a large discoidal *Glomospira* together with a generous scattering of numerous other arenaceous and calcareous forms is yielded by clays from almost all parts of the exposure.

The following list of micro-fossils gives a general idea of the character of the group present in these shales, though but few can be specifically identified at the present time:

Sponge spicules
Conodonts
Ostracods
Foraminifera—
  Thurammina texana Cushman and Waters
  Hyperammina gracilis Waters
  Hyperammina sp.
  Earlandia perparva n. sp.
  Reophax spp.
  Nodosinella perelegans n. sp.
  Ammodiscus incertus (d'Orbigny)
  Glomospira sp.
  Endothyra whitesidei Galloway and Ryniker
  Endothyra watersi n. sp.
  Endothyranella armstrongi n. sp.
  Ammobaculites stenomeca Cushman and Waters
  Ammobaculites spp.
  Textularia sp.
  Spiroplectammina cf. clavata Cushman and Waters
  Bigenerina cf. ciscoensis Cushman and Waters
  Hemigordius regularis n. sp.
  Orthovertella protea Cushman and Waters
  Orthovertella sellardsi n. sp.
  Tetrataxis sp.

SHELL COMPOSITION

TYPES OF PENNSYLVANIAN TESTS

Foraminiferal tests in Texas Pennsylvanian strata according to most popular practice fall into two groups: the imperforate calcareous *(Orthovertella, Hemigordius,* etc.), and the arenaceous *(Textularia, Hyperammina, Endothyra,* etc.).

One of the most irritating inheritances of past decades is the ambiguous term "arenaceous," which has too long been loosely employed to describe all tests not constituted of calcium carbonate secreted from the sea water by some function of the sarcode. The present demand for finer distinctions requires greater precision in descriptive parlance for both morphologic and taxonomic purposes. It is proposed here to adopt the word "adventitious" as a satisfactory comprehensive term to describe all shells composed of any extraneous material bound by cement. The term "arenaceous" will be employed strictly according its etymology, that is, for tests composed of mineral grains obviously selected from their surroundings and cemented into a firm investment by a protoplasmic secretion.

A group that has most commonly been classed as "arenaceous" may prove in the light of future evidence to be bound by a definite biologic character that expresses itself in an investment composed largely of crystalline calcareous particles or minute granules held together by a calcareous cement. These forms were described as "subarenaceous" by Brady,[2] as the minute particles of calcium carbonate precipitated from super-saturated sea waters were, under the conditions of limestone deposition, more available than siliceous grains. That these granular crystalline tests are truly adventitious is probably open to question. Present evidence is by no means convincing. It is therefore urged that tests of this group be described by terms more definitive of their true composition.

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[2]Brady, H. B., A Monograph on Carboniferous and Permian Foraminifera: Paleontological Society, London, 1876.

The three groups of tests occurring in Texas Pennsylvanian strata based on shell composition are:

1. Amorphous calcareous *(Cornuspira, Hemigordius, Orthovertella, Calcitornella, Ammovertella,* etc.)
2. Granulo-crystalline calcareous *(Endothyra, Nodosinella, Tetrataxis, Glyphostomella, Globivalvulina, Bradyina, Endothyranella,* etc.).
3. Arenaceous *(Textularia, Bigenerina, Reophax, Ammobaculites, Hyperammina,* etc.).

ISOMORPHISM

The relationship of environment to shell composition amongst foraminifera is a much-contested problem. In the first comprehensive treatment of Carboniferous forms, Brady described the shell composition of such tests as that of *Endothyra* as "subarenaceous," or composed typically of calcareous grains. In his description of the genus *Endothyra* he states,[3] "the texture of the shell in *Endothyra* is to a greater or less extent arenaceous; that is to say, built up of minute particles of sand (necessarily in these limestone seas, of calcareous sand) embedded in a calcareous cement." This early investigation was based on material collected largely from the great limestone series of Carboniferous and Permian age in Great Britain and from a few shales closely associated with these heavy calcareous strata. That many organisms in this environment employed particles of calcareous carbonate precipitated from these supersaturated sea waters rather than the less available siliceous sand grains was a plausible conclusion and the logical reason for regarding such tests as members of the so-called "arenaceous" group. This theory that shell composition is a direct response of the organism to its environment or to the availability of extraneous material is still widely entertained and is undoubtedly valid as applied to some series of forms.[4]

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[3]Idem, p. 91.

[4]A *Clavulina* on a sandy bottom may construct its test of sand grains only, whereas in the presence of an abundance of minute globigerine tests, some of these may be included with the sand grains in the shell composition. Heron-Allen and Earland have by a study of Antarctic forms (Terra Nova Expedition) followed changes from typically porcellaneous tests of certain miliolid species to arenaceous tests of the same species in the colder areas. Transition forms showing siliceous sand grains sparsely scattered over a porcellaneous test are frequent.

Just how extensively it ought to be employed to explain isomorphism in general is still a mooted question.

In Texas, shales and sandy shales predominate as the lithologic units in the Pennsylvanian section, yet granulo-crystalline calcareous foraminiferal tests are found well developed and in places abundant. The compact, homogeneous, and purely argillaceous shale of the Bridgeport excavations is devoid of any trace of calcareous deposits, yet the variety and abundance of tests of this shell composition are striking. Further, four pairs of isomorphous structures have developed together under the same conditions, at the same time, and on the same sea bottom: *Hemigordius* and *Glomospira, Hyperammina* and *Earlandia* n. gen., *Reophax* and *Nodosinella,* and *Ammobaculites* and *Endothyranella.* These associations challenge too broad an application of this theory of response to environment and to availability of extraneous materials in shell composition.

The exact mechanical and physiological processes that contribute to the construction of the granulo-crystalline calcareous tests are perhaps less obvious than are those of other groups. The presence of numerous tests of this composition in many argillaceous deposits, and the noteworthy abundance and variety of these forms associated with numerous arenaceous species in an unusually pure shale arouses doubt as to the validity of their position as a subdivision of the so-called "arenaceous" group. As one very large group of foraminifera possesses some definite protoplasmic power that enables it to construct hyaline tests of fine radially crystalline structure, it is not inconceivable that this group possessed an analogous power that enabled the organism to secrete from the sea water and to crystallize at the same time the constituent granules embedded in a calcareous cement. Whether the fundamental biologic factors constitute differences that discriminate merely between extraneous calcareous grains and extraneous siliceous grains, or whether they involve a distinction between the power to construct an adventitious test and the power

to secrete entirely its testiferous materials is probably a question that can not at present be satisfactorily answered. Observations do, however, point strongly to two separate and distinct inherent potentialities that control the resultant shell composition.

ALTERATIONS OF TESTS

Because various geochemical processes operative through a long period of time have necessarily modified many remains of fossil organisms, the interpretation of many altered tests of Pennsylvanian foraminifera is beset with formidable difficulties. The study of a representative suite of samples, especially of material rich both in individuals and in genera and species, is particularly valuable to the problem of distinguishing between original salient specific characters and those features in the fossils that have resulted from external forces.

Arenaceous tests.—Many truly arenaceous forms in the Texas Carboniferous strata are found more or less deformed as fossils, a condition that is frequent in all strata. During life of the protoplasm chambers were inflated and were arranged according to definite symmetrical plans. As arenaceous forms are probably the most primitive, some of the variation in these early forms is undoubtedly due to instability in the finer details of structure. The major contributing cause, however, is probably the effect of small deformational stresses of sedimentation upon somewhat plastic shell walls. Only the youngest and most fragile portion of an arenaceous test may exhibit deformation or collapse (*Gaudryina* cf. *pupoides* d'Orbigny of Navarro strata). The entire test may look deflated (*Trochammina arenosa* Cushman and Waters of the Brad formation); or the normal axis of an elongate form may be bent or twisted (*Ammobaculites spirans* Cushman and Waters of the Mineral Wells formation). Differentiation between structures of morphological significance and true deformation is usually possible after studying numerous specimens of each species under consideration. Satisfactory reconstruction is

not always possible, but persistent search is frequently rewarded by a rare normal test.

The cementing material of these arenaceous tests is so tough and durable, and the siliceous minerals employed in the masonry so stable, that they resist disintegration by weathering and the ordinary processes of mineralization that have affected Texas Pennsylvanian strata. Casts of arenaceous tests have not been found in any material studied. Roughness of calcite casts in Pennsylvanian sediments of this area is clearly a secondary deposit of calcium carbonate from percolating waters and should not be interpreted as impressions of an original sandy covering that has worn away. Wherever such casts have been found, persistent search has usually yielded some trace of the original thin, white, amorphous, imperforate test (such as that of *Hemigordius),* the type of shell composition that can more safely be assumed in the absence of the original investment.

Calcareous tests.—The calcareous foraminiferal tests of Texas Pennsylvanian strata are of two types. One is the thin, white, amorphous shell *(Cornuspira, Hemigordius, Orthovertella,* etc.). The other is the thicker dense shell composed largely of minute crystalline calcareous particles or granules in a calcareous cement that in some structures probably carries a trace of ferruginous matter *(Nodosinella, Endothyra, Globivalvulina, Endothyranella,* etc.).

Most of the amorphous calcareous tests in these older formations are now represented by clear calcite or dark dense limonite casts. From most of these the original shell has peeled off entirely, though some specimens show traces of the shell matter along depressions between chambers or between whorls. Some casts with traces of the white shell have become encased by a deposit of calcium carbonate. In material collected from an outcrop of Salesville shale (top of Mineral Wells formation) most of the tests of *Hemigordius harltoni* Cushman and Waters have been so exquisitely and completely replaced by crystalline silica that the species from this sample alone might easily have been

described as finely aranaceous. In the same sample, however, all the ostracods present also this same appearance, and replacement is obvious.

The amorphous character of this type of test and its tenuity in these Paleozoic strata render it particularly susceptible to solution by ground water. Even where the original shell endures, it is probably not replaced by crystalline calcium carbonate as are the hyaline tests common in later strata. Upper Cretaceous material that carries myriads of hyaline forms wholly replaced by calcite in all their finest details of ornamentation yields casts of a *Spiroloculina* on which cling fragments of complete tests of the original shell wall. It is possible that species and individuals of this thin-walled and readily disintegrated amorphous type were much more abundant in Pennsylvanian seas than present fossil evidence indicates.

The thicker granular crystalline shell wall by its very crystalline character is more durable than the thin amorphous tests. Its resistance to solution and greater susceptibility to recrystallization are factors that favor fossil tests of excellent preservation in Texas Pennsylvanian strata. Though many of these tests are filled with calcite or limonite, no mineral casts of any of these forms have yet been proved. The multilocular structure of most of the forms in this group, however, are unfavorable to entire casts, and fillings of separate chambers would be almost impossible to identify.

DESCRIPTIONS OF GENERA AND SPECIES

Family HYPERAMMINIDAE

Genus EARLANDIA n. gen.

Test free, very elongate, composed of a globular or subglobular proloculum and an elongate, nonseptate, second chamber; shell wall of minute crystalline calcareous granules bound by a calcareous cement, imperforate, smoothly finished; aperture a broad circular opening at the end of the tube.

Genotype, *Earlandia perparva* n. sp.

The salient distinguishing character of *Earlandia*[5] n. gen. is the constitution of the shell wall, which is identical with that of *Endothyra* and *Nodosinella*. *Hyperammina* is its morphological equivalent with a typically adventitious test (arenaceous in Pennsylvanian strata). *Hyperamminoides*, another very closely allied structure, is composed of fine siliceous sand grains smoothly finished with much siliceous cement and is especially characterized by the constricted aperture at the end of the enlarging second chamber.

EARLANDIA PERPARVA n. sp.

Pl. 1, figs. 2a–c

Test small, very elongate, slender, tapering, straight, arcuate, or crooked; composed of a globular proloculum followed by a long tubular and gradually enlarging second chamber that is faintly constricted at irregular intervals; shell wall of fine, crystalline, calcareous particles bound by a calcareous cement, imperforate; aperture formed by the open end of the tube.

Average length of test 1 mm.; diameter of proloculum from .02 to .03 mm.; average diameter of apertural extremity of tube of mature form about .08 mm.

This species is very common in the clay of the Bridgeport excavation, and in places it is abundant. Like many of the foraminiferal tests in the older sediments, some of the specimens of *Earlandia perparva* n. sp., are flattened or twisted. Deformation is more common in the younger portions of these tests, where the shell wall is as a general rule more fragile. Complete recrystallization of the originally finely granular shell material of specimens in some parts of this outcrop has rendered it translucent. Most forms are filled with limonite.

From *Hyperammina gracilis* Waters, present in large numbers in this same shale, *Earlandia perparva* n. sp. is

[5]This genus has been named for Mr. Arthur Earland, who has made invaluable contributions to the development of this branch of rhizopodology.

readily distinguished by its granular calcareous test and its much smaller size.

Holotype and paratypes, Plummer Collection, S–656, S—657.1, S—657.2. Metatypes at Bureau of Economic Geology, California Academy of Sciences, Walker Museum, Princeton University, U. S. National Museum, Cushman Laboratory, British Museum, and Melbourne National Museum.

Family REOPHACIDAE

Genus NODOSINELLA H. B. Brady, 1876

NODOSINELLA PERELEGANS n. sp.

Pl. 1, figs. 5 a, b

Test small, arcuate, straight or slightly crooked, slender, tapering; proloculum globular followed by a series of 10 to 14 compact, well-defined, and slowly enlarging chambers separated by somewhat constricted thick sutures; shell wall of minute, crystalline, calcareous particles bound by a calcareous cement, imperforate; aperture a central, simple, slightly protuding, constricted, round opening at the end of the last chamber.

Length of average mature test .6 mm. to .8. mm.; corresponding average widths of final chambers .075 mm. to .09 mm. Diameter of proloculum from .02 mm. to .025 mm.

Nodosinella perelegans n. sp. is abundant in the Brownwood shale at Bridgeport. Most of tests are filled with limonite, which exaggerates the features of the shell structure. As sufficient rigidity has been afforded these tests by the numerous thick septa, they exhibit little collapse or deformation.

Holotype and paratype, Plummer Collection, S–658 and S—659. Metatypes at the Bureau of Economic Geology, California Academy of Sciences, Walker Museum, Princeton University, Cushman Laboratory, U. S. National Museum, British Museum, and Melbourne National Museum.

Family LITUOLIDAE

Genus ENDOTHYRA Phillips, 1846

ENDOTHYRA WATERSI n. sp.

Pl. 1, figs. 6a, b

Test slightly elliptical in outline, nautiloid, closely coiled, partially evolute, bilaterally symmetrical, biumbilicate; periphery narrowly rounded, faintly lobate, if at all; whorls partially embracing, two in mature test; chambers slightly inflated, gradually increasing in size, 8 or 9 in final convolution of mature test; sutures radiate, marked by strong elevated limbations that fuse centrally and obscure completely the area of the inner whorls around a small distinct umbilical depression; shell wall composed of minute calcareous particles in a calcareous cement, imperforate; aperture an elongate elliptical orifice near the base of the septal face.

Longest diameter of average mature test about .5 mm., shortest diameter about .4 mm.

Endothyra watersi[6] n. sp. is present with some frequency in some of beds of the shale exposure in Bridgeport. It is especially marked by the strong development of the shell deposit along the sutures and over the inner whorls of the shell. The somewhat elongate outline of the test is distinctive, but the difference between the two diameters is not marked, and this character is likely to be somewhat deceiving in some specimens. Though *Endothyranella armstrongi* n. sp., in its coiled stage is typically much rounder in outline, rare specimens are slightly elongate.

Holotype, Plummer Collection, S—660. Metatypes at Bureau of Economic Geology, California Academy of Sciences, Walker Museum, Princeton University, Cushman Laboratory, U. S. National Museum, British National Museum, and Melbourne National Museum.

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[6]This species has been named for J. A. Waters, who has done some excellent work on Paleozoic foraminifera of the Mid-Continent area.

ENDOTHYRA WHITESIDEI Galloway and Ryniker

Pl. 1, figs. 7a, b, 8

Endothyra whitesidei Galloway and Ryniker, 1930, Okla. Geol. Survey Circular No. 21, p. 12, pl. 2, fig. 4.

Test discoidal, closely coiled, almost symmetrical bilaterally, strongly evolute; periphery rounded, distinctly lobate; whorls 2 to 2½ in mature tests, partially embracing; chambers 7 in final whorl, inflated, slowly increasing in size; sutures sharply depressed, straight or only faintly curved, distinctly oblique; shell wall rather thin, composed of very fine crystalline, calcareous particles bound by a calcareous cement; aperture a moderately arched opening at the base of the septal face.

Diameter of average mature specimen about .6 mm.

Endothyra whitesidei is rather frequent in the clay of the excavation in Bridgeport. The commonly collapsed condition of these fossil tests suggests that the original wall was somewhat plastic and readily susceptible to deformation after the death of the organism. Probably the lack of reinforcement in sutural limbation, a feature of the other related forms in this faunule, is one of the contributing causes to the flattened, wrinkled, and twisted condition of the tests.

Its rather bold test with only seven chambers in the final convolution and its markedly oblique sutures are distinctive characteristics that separate this species clearly from *E. watersi* n. sp. and from the young coiled tests of *Endothyranella armstrongi* n. sp.

Plesiotypes, Plummer Collection, S—661 and S—662. Other plesiotypes at Bureau of Economic Geology, California Academy of Sciences, Walker Museum, Princeton University, Cushman Laboratory, U. S. National Museum, British Museum, and Melbourne National Museum.

Genus ENDOTHYRANELLA Galloway and Harlton, 1930

Endothyranella Galloway and Harlton, 1930, Okla. Geol. Survey Circular No. 21, p. 13.
Endothyranella, Galloway and Harlton, 1930, Jour. Pal., vol. 4 (Mar.) pp. 24–28.

Test free, spiral in its early portion followed by a straight succession of chambers in full maturity; early coil wholly involute to partially evolute and bilaterally symmetrical to somewhat unsymmetrical; chambers numerous, simple (not labyrinthic); periphery narrowly to broadly rounded; shell wall composed of minute crystalline calcareous granules bound by a calcareous cement; aperture a simple arched orifice at or near the base of the septal face of the young coiled test, terminal and round on final chambers of the straight series of the mature test.

From *Endothyra* this genus is distinguished mainly by the rectilinear succession of its last chambers in the fully mature test. Whether the highly arched character of the aperture is a generic feature is exceedingly doubtful, for *Endothyra media* Waters, *E. grandis* Waters, and *E. ovata* Waters possess this type of orifice, and at the type locality for these forms (Brad formation near Brownwood) where they are quite abundant no tests with any rectilinear succession have yet been observed. It is much more likely that the true endothyrine aperture can vary from a low to a high arch at or near the base of the septal face.

In a list of transfers of previously described Carboniferous species from other genera to *Endothyranella*, Galloway and Harlton (Jour. Pal., vol. 4, pp. 26–28, 1923) have included the following partially coiled Pennsylvanian forms collected from Texas outcrops: *Ammobaculites minuta* Waters, *A. spirans*, Cushman and Waters, *A. gracilis* Waters, *A. nitida* Waters, *A. inconspicua* Cushman and Waters, *A. stormi* Cushman and Waters, and *A. stenomeca* Cushman and Waters (questionably placed under *Endothyranella*). *A. stormi* Cushman and Waters at its type locality is truly an *Endothyranella*. No typical specimens of *A. nitida* Waters have been available for study. The

other species above listed have been observed from material collected at their type localities, and their tests are found to be coarsely arenaceous for their small sizes with siliceous cement. As no evidence of a calcareous foundation for these siliceous grains is now present in the specimens, it is assuming too much to make this generic change on the basis of some obscure ancestry. If it is assumed that the original cement has been replaced by silica, why have not the tests of accompanying endothyrine forms in the same material also been silicified? At this early stage in the investigations of Paleozoic foraminifera too much is being said about ancestry. Until records far antedating the Carboniferous faunas have been carefully read (as already started by W. L. Moreman, Jour. Pal., vol. 4, pp. 42–59, 1930) and precise descriptions of species made available for broad and comparative studies, statements regarding ancestry in these primitive groups must be taken as purely speculative.

In the Texas Pennsylvanian section this genus is represented as low as the Mineral Wells formation where *Endothyranella stormi* (Cushman and Waters) is frequent.

ENDOTHYRANELLA ARMSTRONGI n. sp.

Pl. 1, figs. 9–15

Test crosier-shaped, coiled portion discoidal, bilaterally symmetrical to slightly unsymmetrical, series of rectilinear chambers at tangent to coil and straight; periphery broadly rounded, distinctly but not deeply lobate; whorls 3 to 3½ in coiled portion, slightly embracing; chambers numerous, inflated, usually 9 in final convolution of well developed coil, slowly increasing in size, sutures radiate or very slightly oblique, limbate but depressed and forming a thick dark band between the chambers; shell wall of finely crystalline calcareous granules in calcareous cement; aperture typically endothyrine in coiled test, terminal and round on final chamber of the straight series.

Diameter of fully developed coil about .4 mm.; length of three straight chambers about .35 mm.

In the Brownwood shale of the Bridgeport clay pit *Endothyranella armstrongi*[7] n. sp. is the most abundant calcareous species, and in some samples it has been found in large numbers. Some of the specimens are filled with calcite, but those filled with limonite exhibit strikingly the details of their structure, especially when damp. Most of the drawings have been made from the types in a condition wet enough to bring out the diagnostic features. The uniserial succession in full maturity consists most commonly of two or three chambers, but as many as six have been observed. Though the limbation consists mainly of a thickening of the depressed sutures into dark bands, this development extends along the junction of adjacent whorls and in places obscures small portions of the central part of the test, especially on specimens that exhibit a slight deviation from bilateral symmetry.

The strong evolute convolutions unobscured by thick deposits of secondary shell material and the rounder outline of the coil mark the young stage of this species from *Endothyra watersi* n. sp. *Endothyranella stormi* (Cushman and Waters), described from the Mineral Wells formation is wholly involute in its coiled portion and has only five or six chambers in the whorl.

Holotype, Plummer Collection, S–663; paratypes, S–664.1 to S–664.5, S–66. Metatypes at Bureau of Economic Geology, California Academy of Sciences, Walker Museum, to S—664.5, S—665. Metatypes at Bureau of Economic Geology, California Academy of Sciences, Walker Museum, Princeton University, Cushman Laboratory, U. S. National Museum, British Museum, and Melbourne National Museum.

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[7]This species has been named for J. M. Armstrong, Chief Geologist for Prairie Oil Co. in Texas, who has contributed generously to the Cooperative Mapping Committee, Bureau of Economic Geology.

Family OPHTHALMIDIIDAE

Genus HEMIGORDIUS Schubert, 1908

HEMIGORDIUS REGULARIS n. sp.

Pl. 1, fig. 1

Test free discoidal, circular in outline, early portion of long nonseptate tube coiled in various planes till a diameter of about .05 mm. has been attained, later coiling planispiral up to an average diameter of about .3 mm.; periphery rounded; aperture formed by the open end of the tube.

This species is very rare in the clay of the Bridgeport excavation. The original shell material on most specimens has disappeared leaving a clear crystalline calcite cast. Between the coils, however, the shell matter remains and serves to accentuate the early structure of the test. *Hemigordius harltoni* Cushman and Waters has a much larger irregular early coil. It is interesting to observe in great abundance in this shale the arenaceous isomorph of *H. regularis* n. sp., a rather coarse, flat, discoidal *Glomospira,* the center of which is occupied by a small coil in various planes.

Holotype, Plummer Collection, S—653; metatype at Bureau of Economic Geology.

Genus ORTHOVERTELLA Cushman and Waters

ORTHOVERTELLA PROTEA Cushman and Waters

Pl. 1, figs. 4a, b

Orthovertella protea Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 45, pl. 6, figs. 3, 4.

Test free, consisting of a proloculum followed by a long nonseptate tubular chamber that coils in various planes like a crude ball of twine till an average diameter of about .18 mm. is attained, after which development it becomes straight; shell wall thin, white, calcareous, imperforate, aperture the open end of the tube.

This species is rare in the Brownwood shale near Bridgeport and has been found in very few samples. Most specimens are merely calcite casts, but fragments of the original shell have been observed. Commonly these casts exhibit

rough surfaces that are likely to be interpreted as impressions of sand grains of an arenaceous investment that has disintegrated. As already stated, arenaceous tests probably do not disintegrate and leave casts. This roughness is clearly a deposit of calcium carbonate from percolating waters.

Plesiotypes, Plummer Collection, S–654.

ORTHOVERTELLA SELLARDSI n. sp.

Pl. 1, fig. 3

Test free, consisting of a globular proloculum followed by a long nonseptate tubular second chamber that forms in its early development a small tight irregular coil followed by a straight extension that turns back upon itself and in full development reaches the early coil of the test; shell wall thin, calcareous, white, amorphous, imperforate; aperture formed by the open end of the tube.

Diameter of early tight coil about .1 mm.; length of straight portion of tube to point of doubling back about .4 mm.

Orthovertella sellardsi[8] n. sp. is very rare in the shale of the Bridgeport Brick plant and has been observed in few samples. It has been seen in several other outcrops of Pennsylvanian shales in north-central Texas area and is everywhere distinct from *O. protea* Cushman and Waters by its smaller early coil and the doubling back of the straight tube in maturity.

Holotype, Plummer Collection, S—655. Metatype at Bureau of Economic Geology.

Family ORBITOLINIDAE

Genus TETRATAXIS Ehrenberg, 1843

TETRATAXIS sp.

A single specimen of a form that somewhat resembles *Tetrataxis corona* Cushman and Waters has been found in the series of samples studied from the Brownwood clay at Bridgeport.

[8]This species has been named for Dr. E. H. Sellards, Associate Director of the Bureau of Economic Geology

FORAMINIFERA OF THE CISCO GROUP OF TEXAS

(EXCLUSIVE OF THE FUSULINIDAE)

By

JOSEPH A. CUSHMAN and JAMES A. WATERS

INTRODUCTION

The foraminifera of the Pennsylvanian and Permian of Texas and neighboring states have assumed a great economic importance in relation to subsurface geologic studies. To distinguish the various forms is first necessary, after which their vertical ranges in any particular section may be determined. The present paper is intended to give figures and descriptions of the upper Pennsylvanian group and should be regarded only as a beginning on which to build a much greater knowledge of the fauna. The Fusulinidae are not included here as that family is a specialized one which should be dealt with by someone who has devoted particular attention to that difficult group. The authors have not felt that they were sufficiently well acquainted with this family to include it with the other foraminifera described here.

A short bibliography of works dealing with the Pennsylvanian and Permian foraminifera other than those devoted especially to the Fusulinidae is given. The types of most of the species are in the collection of the Cushman Laboratory for Foraminiferal Research. Duplicate sets are to be deposited in the collections of the Bureau of Economic Geology at Austin, Texas, of the U. S. National Museum at Washington, D.C., and of the University of Oklahoma, Norman, Oklahoma.

ACKNOWLEDGMENTS

We are greatly indebted to Dr. F. H. Lahee and the Sun Oil Company for their coöperation in the collection of material and for permission to publish the results of the studies

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of the microfauna. To Dr. F. B. Plummer, we are much indebted for his kindness in checking over the stratigraphic position of the sample stations with the junior author. We are greatly indebted to Dr. E. H. Sellards and the Bureau of Economic Geology for publishing this paper.

DESCRIPTIONS OF FIELD STATIONS

Station C–1.—This sample station is located one mile west of the town of Graham in Young County, Texas. At this locality a bluff overlooks the Little Salt Fork of Brazos River. At the top of the scarp the Avis sandstone and conglomerate grades downward into a sandy shale and calcareous shale of the Wayland member of the Graham formation of the Cisco. Below the Wayland shale, a thin ledge of Gunsight limestone and South Bend shale occur successively. The South Bend shale consists of about two feet of calcareous shale grading rather abruptly into lignitic shales which in turn are underlain by grey sandy shales.

This locality is one of the best for obtaining micro-fossils from the Cisco division of the Pennsylvanian. The sandy shale of the Wayland member carries an agglutinated arenaceous fauna. The genera *Nodosinella, Hyperamminoides, Ammodiscus, Trochammina,* and other shallow-water forms are present in these shales. The calcareous shales of the Wayland member are very prolific in agglutinated calcareous foraminifera and more significant to the student of phylogeny of the genera is the presence of imperforate calcareous forms. A similar fauna is found in the shale below the Gunsight limestone. The genera *Tetrataxis, Glyphostomella, Climacammina, Endothyra, Plummerinella, Calcivertella, Globivalvulina,* and other deep-water forms are abundant and perfectly preserved, the original composition of the test being retained. The lignitic and sandy shales of the South Bend shale member are unusually fossiliferous. Minute species of *Trochammina, Ammodiscus, Bigenerina, Hyperamminoides, Textularia,* and *Nodosinella* are abundant. The demarcation between the zones of calcareous agglutinated forms and the agglutinated siliceous arenaceous forms is very marked, there being no intermingling of the two groups; the former living only in the deep-water sediments, the latter in the near-shore deposits. A very few of the genera that occur in the sandy shale also are found in the limestone and calcareous shales. These genera are similar only in the arrangement of the chambers and apertural openings, varying in composition of the tests, texture, amount of cement, and size.

Station C–2.—This sample station is located about 4 miles southeast of Graham on the old Graham-Graford road in Young County, Texas. A thin ledge of weathered Bunger limestone is exposed in the ditch

beside the road. The sandy shales of the Gonzales Creek member of the Graham formation below yield a sparse fauna of agglutinated arenaceous foraminifera. The genera *Nodosinella, Reophax, Hyperamminoides,* and *Ammodiscus* are present in these shales.

Station C–3.—This sample station is located 3.3 miles northeast of South Bend in Young County, Texas. The yellowish-white Bunger limestone is 6 to 8 feet thick in this locality. A thin bed of calcareous grey shale of the Gonzales Creek member of the Graham formation is exposed below the limestone. *Fusulinae* are abundant in both the limestone and the shale beneath. Associated with the *Fusulinae* is a very good agglutinated calcareous deep-water fauna. This fauna is very similar to the one in sample station C–1.

Station C–4.—This sample station is located 3.4 miles by road southeast of the courthouse in Jacksboro, Jack County, Texas. The Finis shale member of the Graham formation is exposed in the Gulf, Texas and Western Railway cut west of the viaduct on the Jacksboro-Perrin road. The shales are dark colored, sandy, and thin-bedded, lying stratigraphically below the Jacksboro limestone of the Graham formation of the Cisco group and above the Home Creek limestone, which is the uppermost member of the Canyon group.

Station C–5.—This sample station is located in the same railway cut as C–4 but lies east of the viaduct, where an exposure of white limestone is underlain by calcareous shale. A *Fusulina* bed is present at the base of the limestone and at the top of the shale. This is the Jacksboro limestone and carries an abundant agglutinated calcareous fauna. The micro-fauna of the shale is similar to that of the limestone but is not so well preserved. The genus *Deckerella* is very abundant at this locality.

Station C–6.—This sample station is located 3.7 miles by road southeast of the courthouse in Jacksboro, Jack County, Texas, where a viaduct spans the Rock Island Railway cut in which is an exposure of shale that underlies a *Campophyllum* limestone bed. This shale is weathered to a buff color, and both the micro-fossils and megascopic forms are poorly preserved. This shale belongs to the Finis member of the Graham formation.

Station C–7.—This sample station is located about 7 miles northwest of Breckenridge in Stephens County, Texas. From 15 to 20 feet of lignitic shale are exposed below the Saddle Creek limestone. The fauna from this shale is very limited, but a number of agglutinated arenaceous forms may be obtained from a fair-sized sample.

Station C–8.—This station is located in the upper Breckenridge limestone 1 mile south of Breckenridge in Stephens County, Texas. A few deep-water agglutinated calcareous forms may be obtained at this station. Foraminifera from the shale are too weathered for identification.

Station C–9.—This station is located one-half mile south of Gunsight in Stephens County, Texas. The calcareous Wayland shales at this point carry a very good agglutinated calcareous fauna but not so great a variety of genera as at sample station C–1.

Station C–10.—This station is located 1 mile south of Gunsight on the main road to Cisco in Stephens County, Texas. The Gunsight limestone at this place consists of two thin limestones with sandy and calcareous shales between. The lower limestone is made up largely of cup-corals that have weathered out in great numbers. The micro-fauna obtained from the shales between the limestones is rather mediocre, the number and variety being much inferior to faunas from the same horizon in other localities.

Station C–11.—This sample station is located about 14½ miles north of Ranger in Stephens County, Texas. It is approximately four miles south of Caddo, Texas. An exposure of sandy shale lies above the Home Creek limestone where the main highway cuts through a small hill. This shale yields a good agglutinated arenaceous fauna and a few agglutinated calcareous forms lower in the bed. Great numbers of the genus *Hyperamminoides* may be washed from these shales.

Station C–12.—This sample station is located 1 mile northwest of Cisco in Eastland County, Texas. Several feet of Saddle Creek limestone are exposed at this place. A limited fauna may be obtained from the marl partings in the limestone. Agglutinated arenaceous foraminifera were noted in the shales below the limestone, but good specimens were not present after washing.

Station C–13.—This station is located one-half mile south of Jacksboro on the Jacksboro-Perrin road, Jack County, Texas. The Jacksboro limestone ledge that outcrops on this road yields a very sparse fauna because of the scarcity of the marl partings.

Station C–14.—This sample station is located about 2½ miles northeast of Newcastle in Young County, Texas. The shale adjacent to the Newcastle coal horizon carries a great number of *Textulariae* which are very minute and all of one species.

Station C–15.—This sample station is located about 1½ miles northeast of Camp Colorado in Coleman County, Texas. Several feet of Camp Colorado limestone and shale are exposed where the road crosses the escarpment. Calcareous shale beds alternate with the limestone. The exposure is unweathered yielding a very well-preserved and interesting fauna. The group from these shales consists of many of the genera found in calcareous shales of Permian age but in addition the common genera obtained from horizons lower in the Cisco. A study of this limestone leads to the conclusion that the conditions of sedimentation under which it was laid down were similar to those under which many of the Permian limestones were deposited, hence the similarity in the faunas.

Station C–16.—This sample station is located 10 miles northeast of Breckenridge on the South Bend road in Stephens County, Texas. The excavation for the highway has exposed fresh calcareous and sandy shales. The sandy shales are almost barren of foraminifera, but the calcareous shales of the Wayland member of the Graham formation of the Cisco yield a well-preserved fauna. The group from this station is very similar to that from Station C–1.

Station C–17.—This sample station is located southeast of Cross Plains in Brown County, Texas, where the Gunsight limestone crosses the Brownwood road. The limestone at this locality carries a great number of cup-corals. A very thin bed of shale is exposed below the limestone, but a number of well-preserved foraminifera may be obtained from it.

Station C–18.—This sample station is located 7 miles northeast of Trickham in Brown County, Texas, on the Brownwood road. Lignitic shales of the Graham formation are exposed in a ditch along the highway. Agglutinated arenaceous forms are abundant in these shales.

Gaptank sample station.—This sample station is located at the type locality of the Wolf Camp formation at Wolf Camp, Brewster County, Texas. Two rather massive limestones occur with shales adjacent. The samples from which the arenaceous fauna was taken were collected below the lower limestone of the Gaptank formation. A very good and well-preserved agglutinated calcareous fauna is present in the calcareous shales below the upper limestone.

Some average thicknesses for members and subdivisions of the Cisco group in the areas in which collections were made are listed with the following section.

Formation	Thickness Feet	Member	Thickness Feet
Putnam	150	Coleman Junction limestone	4
		Santa Anna Branch shales	145
Moran	200	Sedwick limestone	8
		Santa Anna shales	50
		Horse Creek limestone	10
		Watts Creek shale and sandstone	60
Pueblo	140	Camp Colorado limestone	5
		Shale	80
		Stockwether limestone	2
		Camp Creek shale	50
Harpersville	175	Saddle Creek limestone	3
		Shale and sandstone	40
		Belknap limestone	3
		Shale, limestone, sand, coal	70
		Crystal Falls limestone	2
		Sand and shale	50
Thrifty	145	Breckenridge limestone	4
		Shale	30
		Black Ranch limestone	4
		Shale and sand	30
		Ivan limestone	5
		Shale	30
		Avis sandstone	22
Graham	560	Wayland shale	80
		Gunsight limestone	21
		South Bend shale and sandstone	80
		Bunger limestone	6
		Gonzales Creek shale and sandstone	230
		Jacksboro limestone	25
		Finis shale and sandstone	75

The following maps show the locations of the sample stations from which the best micro-faunas were obtained.

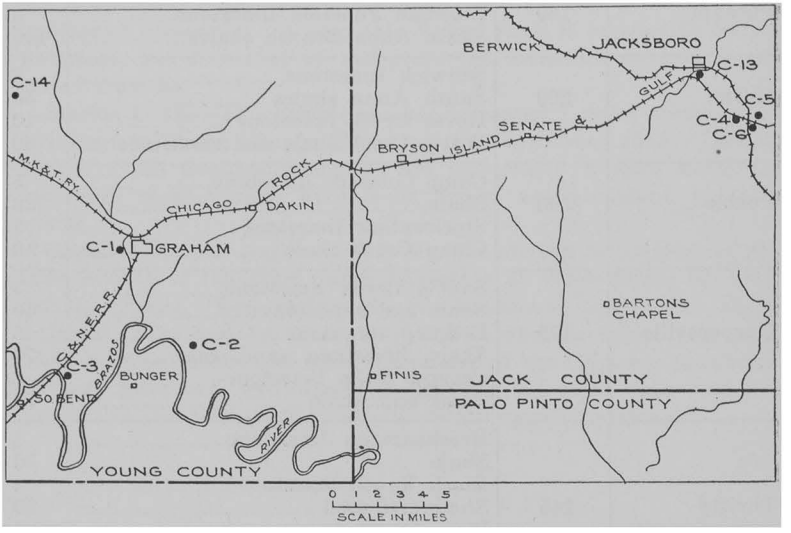

Fig. 1. Map of parts of Young and Jack counties showing fossil localities.

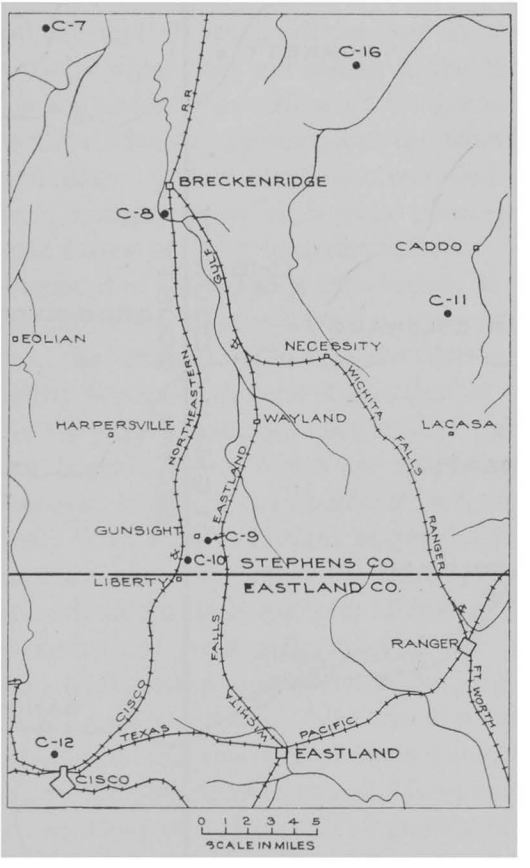

Fig. 2. Map of parts of Stephens and Eastland counties showing fossil localities.

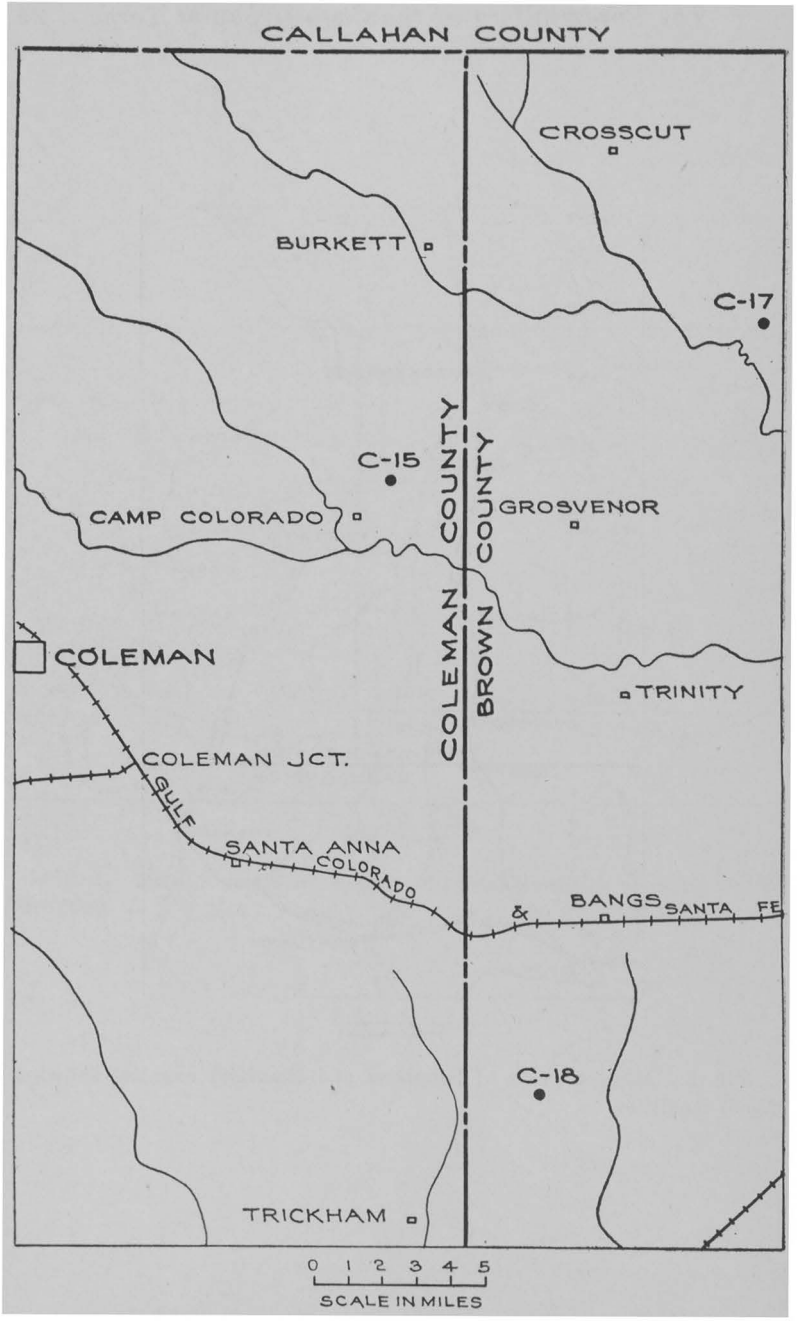

Fig. 3. Map of parts of Coleman and Brown counties showing fossil localities.

GENERAL CHARACTER OF THE FAUNA

A large proportion of the foraminifera of the Cisco are of simple arenaceous types. With the exception of those imperforate calcareous species belonging to the two families of the Miliolidae and Ophthalmidiidae and of the species of *Glyphostomella* which may not belong in the Nonionidae, all the forms are arenaceous. None of the higher families allied to the Rotaliidae are present, and the whole fauna is decidedly primitive. A few forms not recorded here need more material and fuller series of both microspheric and megalospheric forms in order to determine the species.

The development of the fauna is interesting, as the shales with the deeper water species show a preponderance of species with the grains or fragments cemented by a yellowish-brown ferruginous cement like that of many species found in the present oceans under similar habitats. In the shallower deposits many forms are characterized by a calcareous cement, although the fragments may not always be calcareous. With such conditions as represented by the Dothan limestone and some others, a development of imperforate calcareous forms is marked. Some of these such as *Agathammina,* the most primitive of the Miliolidae, show the close relationship to the arenaceous group in their great similarity to *Glomospira.* Likewise the relationship of the Ophthalmidiidae, especially of those primitive forms of the Cisco, to the smoother forms of *Glomospira* is very close and shows their derivation. The genera of the Ophthalmidiidae are all primitive with various structures based on modifications of the simple coiled tube. Some of these, such as *Plummerinella,* are complex in form, yet simple in their primitive structure.

In all the families the simple primitive forms are developed here in the Cisco, but not the higher, more complex ones such as developed in the Mesozoic and Cenozoic. On the other hand, certain specialized types, which in structure

are not complex, apparently mark the climax of their development and are not known in later formations except in the Permian.

The fauna shows strikingly the primitive character of the single-chambered arenaceous forms and of the simple chambered forms in those with several chambers.

In the Hyperamminidae, the genera *Hyperammina* and *Hyperamminoides* represent the simplest forms in the family. In the Reophacidae also, *Reophax* and *Nodosinella* are the simplest genera. The primitive Ammodiscidae are represented by five genera. The Lituolidae are represented by *Endothyra* and *Ammobaculites*. The simplest primitive genera of the Textulariidae, *Spiroplectammina, Textularia,* and *Bigenerina,* are represented by one or more species each, and the genera such as *Climacammina, Deckerella,* and *Geinitzina,* which early reached their climax and became extinct, by a single species each. The only member of the Miliolidae is the most primitive genus, *Agathammina.* The other families are also represented by their simplest, most primitive genera, and from this point of view alone the whole Pennsylvanian is of intense interest.

The futility of attempting to study such faunas as these primitive ones without determining the microspheric and megalospheric forms is shown in *Hyperamminoides elegans* Cushman and Waters (Pl. 1, figs. 6 and 7). The general form is so different in the two forms that without a large series they might be interpreted as two species. The determination of the two forms in any species is very important but nowhere of greater importance than in these primitive arenaceous forms.

The different species exhibit great variation in the amount of cement used, a character that is equally marked in the arenaceous forms of the present oceans. In some species of *Glomospira* angular arenaceous fragments are very abundant, and in others the fine ferruginous cement is greatly predominant. From these to the calcareous imperforate group is but a simple step.

From the purely scientific point of view the Cisco foraminifera, as well as those of the older Pennsylvanian are of great interest. From the economic viewpoint they are no less important, as the careful determination of the vertical range of species will give excellent data for subsurface geologic work.

DESCRIPTIONS OF CISCO FORAMINIFERA

Family HYPERAMMINIDAE

Genus HYPERAMMINA H. B. Brady, 1878

Genoholotype, *Hyperammina elongata* H. B. Brady

Hyperammina H. B. Brady, 1878, Ann. Mag. Nat. His., ser. 5, vol. 1, p. 433; Rep. Voy. *Challenger*, Zoology, 1884, vol. 9, p. 257; Chapman, The Foraminifera, 1902, p. 124; Cushman, Special Publ. No. 1, Cushman Lab. Foram. Res., 1928, p. 83.

Rhabdopleura (?) Dawson, 1871, Ann. Mag. Nat. Hist., ser. 4, vol. 7, p. 86.

Bactrammina Eimer and Fickert, 1899, Zeitschr. Wiss. Zool., vol. 65, p. 673.

Test free, elongate, consisting of a proloculum and long undivided tubular second chamber; wall of sand grains, often with sponge spicules, the amount of cement varying in different species, interior with a chitinous lining and smoothly finished; aperture formed by the open end of the tube.

Cambrian (?), Silurian to Recent.

Species of this primitive genus are very abundant in many parts of the Pennsylvanian.

HYPERAMMINA GLABRA Cushman and Waters

Pl. 2, figs. 1–3

Hyperammina glabra Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 146, pl. 26, fig. 1.

Test elongate, consisting of an oval proloculum and an elongate, tubular, second chamber, very slightly tapering from the narrowest diameter near the proloculum to the greatest width near the apertural end, usually slightly constricted in places with apparently lines of growth, round

in transverse section; wall of fine arenaceous material with much cement, the surface smooth, matte; aperture formed by the open end of the tube.

Length up to 3 mm.; greatest diameter of perfect specimens 0.12–0.20 mm.; diameter of microspheric proloculum 0.06 mm.; diameter of megalospheric proloculum 0.15 mm.

This species was first described from sandy shales 25 feet below the Palo Pinto limestone near the top of the Strawn group, 9 miles east of Graford, Palo Pinto County, Texas. It continues upward into the younger formations, and the figured specimens are from the South Bend shale of the Graham formation of the Cisco, 1 foot below the Gunsight limestone, 1 mile west of Graham, Young County, Texas.

The species may be distinguished by the somewhat tapering form of the second chamber and the large proportion of cement in the wall of the test. The holotype exhibits a slight crushing as noted at the time the species was described, but the tapering is characteristic of most of the specimens examined, microspheric specimens being more strongly tapering. In the collections both forms occur. Figure 2 shows the microspheric form, which has a very small proloculum but tapering second tubular chamber. Figure 1 shows the megalospheric form with larger proloculum and short, nearly cylindrical tubular chamber.

Hyperammina glabra may be distinguished from *H. bulbosa* by the round section of the former, the latter being much compressed by the very fine texture and tapering test of the former, and by the compressed cylindrical form and the much coarser texture of the latter.

HYPERAMMINA BULBOSA Cushman and Waters

Pl. 2, figs. 4, 5

Hyperammina bulbosa Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 109, pl. 22, figs. 7 *a*, *b*.

Test with a fairly large proloculum, broader than the tubular second chamber, whole test compressed, elliptical in transverse section, showing definite constrictions representing lines of growth; wall arenaceous, with a somewhat

roughened surface; aperture formed by the open end of the tubular chamber.

Length of figured specimen slightly less than 1 mm.; breadth of test 0.15 mm.; thickness 0.08 mm.; breadth of proloculum 0.20 mm.; thickness 0.15 mm.

The holotype of this species is from the *Lingulina* bed, below the 20-inch coal bed near Grand Ledge, Clinton County, Michigan. The figured specimen is from the Graham formation below the Gunsight limestone, south of Cross Plains, Texas, on the Brownwood road. This species is also found in the Graham formation 7 miles northeast of Trickham, in Coleman County, Texas.

The tubular chamber is often irregular and marked by distinct constrictions due to cessations of growth.

Genus HYPERAMMINOIDES Cushman and Waters, 1928

Genoholotype, *Hyperamminoides elegans* Cushman and Waters

Hyperamminella Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 36 (not *Hyperamminella* de Folin, 1881).
Hyperamminoides Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 112.

Test elongate, consisting of a proloculum and elongate, somewhat tapering second chamber; wall siliceous or arenaceous with siliceous cement, with numerous constrictions caused by growth intervals but the chamber not definitely divided; aperture at the end of the chamber, circular or elliptical, constricted, sometimes with a trace of lip-like thickening.

Pennsylvanian.

This genus is allied to *Hyperammina* but differs in the constricted apertural end, the siliceous test, and tapering shape.

Numerous species occur in the Pennsylvanian strata, the vertical ranges of which make them useful in stratigraphic work. In brackish water the various species evidently developed chitin very strongly, but most of the fossil tests are so crushed that specific description is almost impossible.

HYPERAMMINOIDES ELEGANS (Cushman and Waters)

Pl. 2, figs. 6–9

Hyperamminella elegans Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 36, pl. 4, figs. 3, 4.

Test elongate, tapering, the microspheric form very pointed at the initial end and rapidly enlarging, the megalospheric form with a large bulbous proloculum and the breadth of the chamber not greatly increasing toward the aperture; interior of tubular chamber slightly constricted but not divided; wall siliceous, very fine grained, exterior smooth and polished; aperture at the constricted end of the tubular chamber, rounded or elliptical.

Length of largest specimen nearly 5 mm.; maximum breadth nearly 1 mm.

The types of this species are from the Graham formation, below the Bunger limestone, 14.7 miles north of Ranger, on the Caddo road, Stephens County, Texas.

This species is a large and conspicuous one and makes an excellent marker for this part of the Pennsylvanian. There is a great difference in the microspheric and megalospheric forms as shown in the figures. Some of the latter are even shorter and broader than the one figured.

HYPERAMMINOIDES GLABRA (Cushman and Waters)

Pl. 12, figs. 2, 3

Nodosinella glabra Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 147, pl. 26, figs. 4, 5.

Test slender, tapering, the initial end occasionally slightly curved, suture-like varices of growth marking the surface, but the interior not completely divided; wall finely arenaceous with very definite grains and a large proportion of cement; apertural end at the widest portion of the test, aperture small, circular, terminal.

Length of holotype 0.75 mm.; breadth 0.17 mm.

This species is common at the type locality in the Graham formation of the Cisco group, from a calcareous shale 6 inches below the Gunsight limestone on Salt Creek west of

Graham, Young County, Texas. It has a wide range from the Canyon group to the Permian. This was originally described as a *Nodosinella,* but a further study of a large series of specimens as well as sections shows it to belong in *Hyperamminoides.*

Family REOPHACIDAE

Genus REOPHAX Montfort, 1808

Genoholotype, *Reophax scorpiurus* Montfort

Reophax Montfort, 1808, Conch. Syst., vol. 1, p. 331; H. B. Brady (part), 1884, Rep. Voy. *Challenger,* Zoology, vol. 9, p. 289; Chapman (part), 1902, The Foraminifera, p. 137; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 93.
Nodosaria (part) of authors (not Lamarck).
Lituola (part) of authors (not Lamarck).
Haplostiche Schwager, 1865, Jahr. Ver. Vet. Nat. Württenburg, vol. 21, p. 92 (not *Haplostiche* Reuss).
Nodulina Rhumbler, 1895, Nachr. kön. Ges. Wiss. Göttingen, p. 85.
Protoshista Eimer and Fickert, 1899, Zeitschr. Wiss. Zool., vol. 65, p. 677.

Test free, elongate, composed of several undivided chambers, ranging from overlapping to remotely separated ones connected by stolon-like necks, in a straight or curved linear series; wall single, of agglutinated material, firmly cemented, sand grains, mica scales, sponge spicules or other foraminifera; aperture simple, terminal, sometimes with a slight neck.

Cambrian to Recent.

The early species show the same selection of material as do the Recent ones, but the variety of material is not so large. Some of the Pennsylvanian species choose very coarse arenaceous grains for the test.

REOPHAX ASPER Cushman and Waters

Pl. 2, fig. 10

Reophax asperus Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 37, pl. 4, fig. 7.

Test elongate, somewhat tapering, generally rounded in section; chambers several, somewhat obscure; sutures not

deeply depressed; wall arenaceous, composed of siliceous grains of angular shape firmly cemented; aperture small, rounded.

Length of type specimen 0.80 mm.; breadth 0.25 mm.

The types of this species are from the Graham formation of the Cisco group, from shale 20 feet below the Bunger limestone, 4 miles southeast of Graham, on the Graford road, Young County, Texas. It is also known to occur below the Bunger limestone about 14.7 miles north of Ranger, Stephens County, Texas.

This is a very coarsely arenaceous species composed of firmly cemented, angular sand grains.

Genus NODOSINELLA H. B. Brady, 1876

Genotype, by designation, *Nodosinella digitata* H. B. Brady

Nodosinella H. B. Brady, 1876, Pal. Soc. Mon., vol. 30, p. 102; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 94.
Dentalina (part) of authors.

Test free, straight or arcuate, chambers usually distinct, typically enlarging in size as added, simple; walls finely arenaceous with much cement, with often a double wall; aperture usually simple and terminal.

Carboniferous to Cretaceous. Widely distributed.

Some species are characterized by an outer wall which is largely cement, smooth, and sometimes seems to be imperforate. Specimens are very abundant in many parts of the Pennsylvanian section.

NODOSINELLA GLENNENSIS Harlton

Pl. 2, figs. 11, 12; Pl. 12, fig. 4

Nodosinella glennensis Harlton, 1927, Journ. Pal., vol. 1, No. 1, p. 17, pl. 1, figs. 4 *a–c.*

Test elongate, tapering, axis straight or slightly curved, five or six chambers in the adult test, sutures usually well marked; wall arenaceous, fairly smoothly finished; aperture large, circular, terminal.

Length up to 2 mm. or more in adults; breadth 0.65 mm.

The figured specimens are not so well preserved as are those from some of the other formations. They are from the Wayland shale of the Graham formation of the Cisco group, 20 feet above the Gunsight limestone on Salt Creek west of Graham, Young County, Texas.

The holotype of this species is refigured in Plate 12, figure 4, and was drawn from the original in Washington. It presents the characters much better than the more or less conventionalized figures given by the original author.

Family AMMODISCIDAE

Genus AMMODISCUS Reuss, 1861

Genotype, by designation, *Operculina incerta* d'Orbigny

Ammodiscus Reuss, 1861, Sitz. Akad. Wiss. Wien, vol. 44, p. 365; H. B. Brady, 1884, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 329; Chapman, 1902, The Foraminifera, p. 150; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 99.

Operculina (part) d'Orbigny, 1839, in De la Sagra, Hist. Fis. Pol. Nat. Cuba, p. 49.

Orbis Strickland, 1848, Quart. Journ. Geol. Soc., vol. 2, p. 30 (not *Orbis* Phillips).

Spirillina Williamson ,1858, Rec. Foram. Great Britain, p. 93 (not *Spirillina* Ehrenberg, 1841).

Trochammina (part) of authors.

Cornuspira (part) of authors.

Involutina (part) Terquem, 1860–1861 (1862), Mém. Acad. Imp. Metz, p. 450.

Test free, planispiral, with a proloculum and long tubular undivided second chamber, coiled regularly in one plane; wall finely arenaceous with a large proportion of yellowish-brown or reddish-brown cement, surface smooth; aperture formed by the open end of the chamber.

Silurian to Recent.

In many Pennsylvanian strata specimens are extremely abundant and form a large part of the foraminiferal fauna in certain beds.

AMMODISCUS SEMICONSTRICTUS Waters var. REGULARIS Waters

Pl. 2, figs. 13–15

Ammodiscus semiconstrictus Waters var. *regularis* Waters, 1927, Journ. Pal., vol. 1, No. 2, p. 132, pl. 22, figs. 2 *a*, *b*.

Test planispiral, biconcave, circular; the coiled chamber increasing very regularly in diameter; wall fairly thick, coarsely arenaceous, the sand grains cemented with a small proportion of cement giving a roughened surface; spiral suture distinct; aperture generally circular at the end of the tubular chamber.

Diameter usually less than 1 mm.

The types of this variety are from the Dornick Hills formation of Oklahoma. It has been found at numerous stations in the Cisco of Texas, and the specimens are very close to the types, possibly a little smaller in some of the outcrops. It occurs in the Wayland shale member of the Graham formation of the Cisco, 5 feet above the Gunsight limestone on Salt Creek west of Graham, Young County, Texas; 3.2 miles south of Jacksboro, Jack County, Texas (west of viaduct); 7 miles northeast of Trickham on the Brownwood road, Coleman County, Texas; in the Gaptank formation at Wolf Camp, Brewster County, Texas; in the top of the Wolf Camp formation 5½ miles east of Hess ranch in Brewster County, Texas.

Genus AMMODISCOIDES Cushman, 1909

Genoholotype, *Ammodiscoides turbinatus* Cushman

Ammodiscoides Cushman, 1909, Proc. U. S. Nat. Mus., vol. 36, p. 24; 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 102.

Test free, consisting of a proloculum and long undivided tubular second chamber, the early coils in a conical spire later spreading out and becoming nearly planispiral; wall finely arenaceous with a large proportion of cement, yellowish- or reddish-brown, smoothly finished; aperture formed by the open end of the tube.

Carboniferous to Recent.

The range of this genus has been greatly extended by its discovery in the Pennsylvanian strata of Texas.

AMMODISCOIDES CONICA Cushman and Waters

Pl. 3, figs. 1 *a*, *b*

Ammodiscoides conica Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 39, pl. 4, figs. 10 *a*, *b*.

Test small, coiled, early portion sharply conical, later coils planispiral, tubular chamber of very uniform diameter; wall arenaceous, smoothly finished; aperture semicircular, at the open end of the tubular chamber.

Diameter of type specimen 0.30 mm.

The types of this species are from the Wayland shale member of the Graham formation of the Cisco, 5 feet above the Gunsight limestone on Salt Creek west of Graham, Young County, Texas.

The species is small and may be easily overlooked, but the central cone will identify it.

Genus GLOMOSPIRA Rzehak, 1888

Genotype, by designation, *Trochammina gordialis* Jones and Parker.

Glomospira Rzehak, 1888, Verh. k. k. Geol. Reichs., p. 191; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 102.

Trochammina (part) Jones and Parker, 1860, Quart. Journ. Geol. Soc. vol. 61, p. 304.

Ammodiscus (part) of authors.

Gordiammina Rhumbler, 1895, Nachr. Ges. Wiss. Göttingen, p. 84.

Test free, consisting of a proloculum and long tubular second chamber winding about its earlier coils in various planes; wall of fine arenaceous material with a large proportion of yellowish- or reddish-brown cement; aperture at the end of the tube.

Carboniferous to Recent.

This genus is very abundant in some parts of the Pennsylvanian of Texas.

GLOMOSPIRA SPINOSA Cushman and Waters

Pl. 3, figs. 2, 3

Glomospira spinosa Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 39, pl. 4, fig. 14.

Test coiled irregularly in a globular form, tubular chamber undivided; wall very finely arenaceous with much cement, firm, exterior with short, pointed, spinose projections

regularly arranged over the surface; aperture formed by the open end of the tubular chamber.

Diameter 0.45 mm.

The types of this species are from the Wayland shale member of the Graham formation of the Cisco, 5 feet above the Gunsight limestone on Salt Creek west of Graham, Young County, Texas. Specimens also occur in the South Bend shale 6 inches to 1 foot below the Gunsight limestone at the same locality.

GLOMOSPIRA REVERSA Cushman and Waters, n. sp.

Pl. 3, figs. 4, 5

Test with the early chambers in varying planes later nearly planispiral, last coils strongly increasing in diameter, all coils somewhat irregular, periphery rounded in well preserved specimens; suture deep; wall rather coarsely finished, of arenaceous material with much cement; aperture somewhat arcuate at the open end of the tubular chamber.

Diameter 0.50 mm.

Holotype (Cushman Coll. No. 9144) from Gaptank formation at Wolf Camp, Brewster County, Texas.

GLOMOSPIRA DIVERSA Cushman and Waters n. sp.

Pl. 3, figs. 9–14

Test in the early stages irregularly coiled but mostly in a generally planispiral manner, the later coils twisting about the early ones in very different planes, the diameter of the coils very gradually increasing as added, the last one in some specimens suddenly larger; wall finely arenaceous with a large amount of cement; aperture at the open end of the tubular chamber, generally semicircular.

Diameter up to 0.35 mm.

Holotype (Cushman Coll. No. 9146) from the Harpersville formation of the Cisco, just below the Saddle Creek limestone, about 6 miles northwest of Breckenridge, Stephens County, Texas. It is common in this material and strongly suggests *Glomospira gordialis* (Jones and Parker).

The Pennsylvanian *G. diversa* is coarser and rougher, and the change in the two divisions is more marked.

GLOMOSPIRA SIMPLEX Harlton

Pl. 3, figs. 6–8

Glomospira simplex Harlton, 1928, Journ. Pal., vol. 1, No. 4, p. 305, pl. 52, figs. 2 *a–c*.

Test small, irregularly shaped, periphery generally rounded, the early coils very irregular, wound irregularly into a rounded mass; wall arenaceous with much cement, the amount of cement increasing in the upper range of the species, surface often finely granular in the more coarsely arenaceous forms; aperture semicircular, formed by the open end of the tubular chamber.

Diameter of test up to 0.40 mm.

The type of this species is given as from the "Gaptank formation, according to Robert and Phillip King, 1½ miles northeast of Wolf Camp, 450 feet below upper Gaptank, Pecos County, Texas." The species occurs in the Cisco particularly below the Bunger limestone, about 14.7 miles north of Ranger, on the Caddo road, Stephens County, Texas. It occurs in the Wayland shale 5 feet above the Gunsight limestone on Salt Creek west of Graham, Young County. It ranges upward in the section, and in the Dothan limestone it is composed almost entirely of cement and is probably the form that gave rise to the Ophthalmidiidae, the cement becoming calcareous and the arenaceous character gradually disappearing. The form of the test in the Dothan limestone is identical with those of the arenaceous forms lower in the section. This is one of the excellent examples of the change of an arenaceous form gradually into a calcareous imperforate one.

Genus AMMOVERTELLA Cushman, 1928

Genoholotype, *Psammophis inversus* Schellwien

Psammophis Schellwien, 1898, Paleontographica, vol. 44, p. 266 (not Boie, 1827).

Ammovertella Cushman, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 8; 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 104.

Test attached, consisting of proloculum and long, tubular, unbranched, second chamber increasing in diameter, the early portion planispirally coiled, later and larger portion bending back and forth, progressing forward in one general direction; wall arenaceous, usually with much cement, aperture formed by the open end of the tube.

Carboniferous to Jurassic.

The species of this genus are found in several parts of the Pennsylvanian and are paralleled in the calcareous imperforate group found in the upper Cisco and Permian.

Galloway and Ryniker (Oklahoma Geol. Surv., Circular No. 21, 1930) have placed several genera as synonyms of this genus, and state that these are probably worm tubes. That these are true foraminifera is shown not only by the structure of the test in sections, but also by the occurrence of both microspheric and megalospheric forms. The various generic characters culminate in the very beautiful complexity in *Plummerinella* which is a striking example of the beauty of form that can be developed in the foraminifera.

To place all these generic and specific forms together is to overlook much of the data that should be used in the study of these primitive but very useful foraminifera.

AMMOVERTELLA INCLUSA (Cushman and Waters)

Pl. 7, fig. 13

Psammophis inclusus Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, 1927, p. 148, pl. 26, fig. 12.

Test attached, basal side flattened, dorsal side convex, consisting of a proloculum and elongate tubular chamber,

the latter in its early stages close coiled planispirally, later the tube swinging back and forth about the early portion and partially embracing it; wall finely arenaceous with much cement and the dorsal surface somewhat roughened; aperture formed by the open end of the tubular chamber.

Maximum diameter of holotype 0.85 mm.

The type locality for this species is the South Bend shale of the Graham formation of the Cisco, 1 foot below the Gunsight limestone on Salt Creek west of Graham, Young County, Texas.

This species differs from *Ammovertella inversa* (Schellwien) in the embracing character of the chambers and in the larger size.

Genus TOLYPAMMINA Rhumbler, 1895

Genoholotype, *Hyperammina vagans*, H. B. Brady

Tolypammina Rhumbler, 1895, Nachr. Kön. Ges. Wiss. Göttingen, p. 83; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 103.

Hyperammina (part) H. B. Brady, 1879, Quart. Journ. Micr. Sci., vol. 19, p. 33.

Serpula Eimer and Fickert, 1899, Zeitschr. Wiss. Zool., vol. 65, p. 674.

Ammonema, l. c., p. 685.

Girvanella (part) of authors (not *Girvanella* Nicholson and Etheridge, 1878).

Test, in the young stages at least, adherent, but becoming free, consisting of an elongate oval proloculum and long undivided tubular second chamber, unbranched, the earliest portion of some species coiled; wall arenaceous with a large proportion of yellowish-brown or reddish-brown cement; aperture formed by the open end of the tube.

Carboniferous to Recent. Very abundant in some parts of the Pennsylvanian of Texas.

TOLYPAMMINA DELICATULA Cushman and Waters

Pl. 7, fig. 12

Tolypammina delicatula Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 62, pl. 8, fig. 3.

Test attached, the early portion coiled in a regular planispiral manner with several coils, later becoming uncoiled

and nearly straight if on a large surface, the tubular chamber at first very slender, but the uncoiled portion in adults becoming larger and often very long compared to the coiled portion; wall distinctly arenaceous usually of more or less even angular grains but firmly cemented; aperture formed by the open end of the tube.

Diameter of coiled portion usually not more than 0.10 mm., but entire test may be several millimeters in length.

The types of this species are from the Wayland shale member of the Graham formation of the Cisco, 5 feet above the Gunsight limestone on Salt Creek west of Graham, Young County, Texas, where they are attached to shell fragments.

This species is a very distinctive one with its very small but regularly coiled early portion and abrupt change to the straight uncoiled portion.

Family LITUOLIDAE

Genus ENDOTHYRA Phillips, 1846

Genoholotype, *Endothyra bowmani* Phillips

Endothyra Phillips, 1844–1845 (1846), Rept. Proc. Geol. Poly. Soc. West. Riding Yorkshire, p. 277; H. B. Brady, 1876, Pal. Soc. Mon. 30, p. 91; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 107.

Involutina (part of authors).

Nonionina Eichwald, 1860, Lethaea Rossica, vol. 1, p. 350 (not *Nonionina* d'Orbigny, 1826).

Test free, close coiled, often completely involute; chambers numerous, distinct, simple; wall arenaceous usually with a large amount of cement, the exterior smoothly finished; wall often double; aperture simple, typically at the base of the apertural face but occasionally above the base.

Carboniferous to Triassic. Very abundant in many Pennsylvanian strata.

The limits of species in this genus are difficult to fix. It has been found possible in our joint work on these collections to separate various forms which under test conditions could be identified in mixed material, but to translate these

differences into terms of scientific description that may be used by others is much more difficult. Sections have been found to be very useful and certain distinctive characters that do not show on the exterior may be revealed by sections. Recurring faunas in the Pennsylvanian of Texas and adjacent regions have very similar species, which need very much study before they can be used with full confidence in stratigraphic work.

ENDOTHYRA MEDIA Waters

Pl. 3, figs. 17 *a*, *b*

Endothyra media Waters, 1928, Journ. Pal., vol. 1, No. 4, p. 273, pl. 42, figs. 11, 12.

Test close coiled, compressed, nearly planispiral, the early stages involute, last-formed coil becoming partially evolute, periphery broadly rounded; chambers usually 10 in the last-formed coil, slightly inflated, distinct; sutures distinct but only slightly depressed; wall arenaceous, with distinct angular grains and calcareous cement, the outer coating often worn away in poorly preserved material leaving a smooth test; aperture, a high arch usually higher than wide.

Diameter 1 mm. or slightly more; maximum thickness 0.32 mm.

This species was originally described from the Canyon division below the Ranger limestone. In the Lower Cisco particularly, some specimens are very close to the Canyon form, and it seems best, for the present at least, to place them under the same name.

The arenaceous test is very marked but may be easily worn away in poorly preserved material and only the smooth wall of the interior remains.

ENDOTHYRA PAUCILOCULATA Cushman and Waters, n. sp.

Pl. 3, figs. 16 *a*, *b*

Test close coiled, completely involute for most of its development but occasionally the last one or two chambers slightly drawing away from the umbilical region, periphery broadly rounded; chambers usually five, occasionally six or

in adults the seventh chamber may make part of the coil; sutures distinct, deep; wall smoothly finished, with an outer arenaceous coating in which the angular grains are very distinct with sufficient enlargement; aperture very broad, extending nearly from umbilicus to the other.

Diameter 0.40 mm.

Holotype (Cushman Coll. No. 9148) from the Wayland shale of the Graham formation, 20 feet above the Gunsight limestone, ½ mile south of Gunsight, Stephens County, Texas. This species occurs in other parts of the Cisco. It is very close to a species found in the Mineral Wells formation of the Strawn group, but it was found possible in the laboratory to distinguish the two under test conditions.

The broadly rounded periphery, few chambers and large aperture will distinguish this species from other Cisco ones.

Genus AMMOBACULITES Cushman, 1910

Genotype, by designation, *Spirolina agglutinans* d'Orbigny

Ammobaculites Cushman, 1910, U. S. Nat. Mus., Bull. 71, pt. 1, p. 114; 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 107.

Spirolina (part) d'Orbigny, 1846, For. Foss. Bass. Tert. Vienne, p. 137.

Haplophragmium (part) of authors.

Test free, the early chambers close coiled, later ones uncoiling with typically a linear series of chambers, simple; wall arenaceous with a chitinous lining; aperture in the early stages at the base of the apertural face, in the adult circular and terminal.

Carboniferous to Recent.

There are numerous species of this genus in the Pennsylvanian strata of Texas, and several of the Cisco species show a great range in the relative coarseness of the material used and in the relative amount of cement.

AMMOBACULITES STENOMECA Cushman and Waters

Pl. 3, figs. 15 *a*, *b*

Ammobaculites stenomeca Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 39, pl. 5, figs. 1 *a*, *b*.

Test small, slender, early portion compressed, close coiled, of few chambers, later portion straight, of 4 or 5 chambers,

also compressed, sides nearly parallel; sutures but slightly depressed; wall coarsely arenaceous for the size of the test, roughened on the surface; aperture narrow, elliptical.

Length 0.60 mm.; breadth 0.20 mm.; thickness 0.10 mm.

The types of this species are from the South Bend shale of the Graham formation of the Cisco, 1 foot below the Gunsight limestone on Salt Creek west of Graham, Young County, Texas.

This is a slender, compressed species of small size, but the material of the test is comparatively coarse and roughly but firmly cemented.

AMMOBACULITES SPIRANS Cushman and Waters

Pl. 7, fig. 10

Ammobaculites spirans Cushman and Waters, 1927, Contrib. Cushman Lab. Foram Res., vol. 3, p. 149, pl. 26, fig. 10.

Test elongate, slender, the early chambers planispirally coiled, later chambers uncoiled but somewhat twisted in their development, so that an irregular biserial form is taken on in some parts of the uncoiled portion; wall arenaceous with a large proportion of cement, surface somewhat roughened; aperture rounded, terminal.

Length of holotype 0.70 mm.; breadth 0.15 mm.

This species was originally described from near the base of the Mineral Wells formation of the upper Strawn at Thurber, Erath County, Texas, and is known from several neighboring localities. The species occurs in typical form in the lower Cisco, 7 miles northeast of Trickham, Coleman County, Texas.

A. spirans is one of the most interesting species of the genus, the chambers of the uniserial portion twisting so as to give an irregularly biserial structure very clearly foreshadowing the forms found in *Spiroplectammina* and through them to the great group of the Textulariidae. In both this species and *Spiroplectammina,* the early chambers are planispirally coiled. In the later chambers, the irregular twisting in *A. spirans* becomes settled to a regular 180°

turning in *Spiroplectammina* as in the other Textulariidae. *Ammobaculites spirans* is an excellent species to show the relationships of these two groups.

AMMOBACULITES RECTA (H. B. Brady)

Pl. 4, figs. 1, 2

Haplophragmium rectum H. B. Brady, 1876, Pal. Soc. Mon. 30, p. 66, pl. 8, figs. 8, 9.

Ammobaculites rectum Harlton, 1927, Journ. Pal., vol. 1, p. 20, pl. 3, figs. 2 *a–c*.

Test elongate, slender, the early chambers planispiral, close coiled, few, involute, later ones in an elongate rectilinear series very slightly if at all tapering, in the early portion about 5 chambers making up a coil, the uncoiled portion with as many as 6 chambers, becoming inflated in the last few; sutures distinct and somewhat depressed; wall smooth, finely arenaceous, with much cement; aperture circular, terminal.

Length up to 1 mm.; diameter of coiled portion 0.25 mm.; thickness 0.20 mm.

Brady's specimens were from Yorkshire, England. Those recorded by Harlton were from Oklahoma. The species occurs in the Cisco at several stations in company with *A. powersi*, and it is suspected that the two are the same species, *A. recta* being the megalospheric form and *A. powersi* the microspheric form. There is a rather uniform gradation from large broad coiled forms with no uncoiled chambers to the small few chambered coiled forms with as many as six uniserial chambers.

AMMOBACULITES POWERSI Harlton

Pl. 4, figs. 3–6

Ammobaculites powersi Harlton, 1927, Journ. Pal., vol. 1, p. 21, pl. 3, figs. 3 *a–e*.

Test in the early stages planispiral, close coiled, in the later portion with several uncoiled chambers, the coiled portion either with the chambers completely involute or tending to become somewhat evolute before the rectilinear

portion is developed, periphery rounded, rectilinear portion rounded in section; chambers distinct, numerous, usually 8 in a coil in the early portion, rectilinear chambers usually only 3; sutures distinct, not greatly depressed; wall arenaceous, mostly of fine angular fragments but occasionally with scattered larger fragments, cement in large proportion, exterior rather smoothly finished; aperture rounded, terminal.

Length up to 2 mm.; breadth 1.25 mm.; thickness 0.50 mm.

This species was originally described from the lower Glenn of Love County, Oklahoma. It occurs abundantly in some parts of the Cisco and is well developed above and below the Gunsight limestone on Salt Creek west of Graham, Young County, and in the Graham formation, 10 miles northeast of Breckenridge, Stephens County.

Family TEXTULARIIDAE

Genus SPIROPLECTAMMINA Cushman, 1927

Genoholotype, *Textularia agglutinans*, var. *biformis* Parker and Jones

Spiroplectammina Cushman, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 23; 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 114.

Textularia (part) Parker and Jones (not Defrance), 1865, Philos. Trans., vol. 155, p. 370.

Spiroplecta H. B. Brady (not Ehrenberg), 1884, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 376.

Test free, early chambers planispiral in both microspheric and megalospheric forms, later ones biserial; wall arenaceous with a yellowish-brown cement; aperture in the planispiral portion at the base of the apertural face, in the biserial portion at the inner margin of the chamber.

Carboniferous to Recent.

This genus represents a simple radicle from which the whole family of the Textulariidae has developed, the biserial portion best regarded as a spiral coiling about an elongate axis, each chamber representing a turn of 180° from the preceding, and two chambers completing a whorl.

SPIROPLECTAMMINA CLAVATA Cushman and Waters

Pl. 4, figs. 7, 8

Spiroplectammina clavata Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 150, pl. 27, figs. 2 *a*, *b*; 1928, vol. 4, p. 42, pl. 5, figs. 5 *a*, *b*.

Test elongate, clavate, early chambers in an irregular planispiral coil, of numerous chambers, periphery rounded, later chambers biserial, about as high as broad; sutures for the most part fairly distinct, but only slightly depressed; wall thick, of a few coarse fragments with numerous smaller ones and a large amount of cement, surface smooth; aperture in the adult, textularian, fairly high.

Length up to 0.75 mm.; breadth 0.25 mm.; thickness 0.10 mm.

This species was described from the South Bend shale member of the Graham formation of the Cisco, 6 inches below the Gunsight limestone on Salt Creek 1 mile west of Graham, Young County, Texas.

This species is peculiar in its rectangular form, but it is constant in its characters.

SPIROPLECTAMMINA CASTENSIS Cushman and Waters

Pl. 7, figs. 11 *a*, *b*

Spiroplectammina castensis Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 62, pl. 8, figs. 4 *a*, *b*.

Test broad, much compressed, about twice as long as wide; chambers in the early portion planispirally coiled, later ones biserial; sutures only slightly depressed; wall arenaceous, of a mixture of coarse and fine grains making a rough surface, firmly cemented; aperture elongate, arched, at the center of the inner margin of the final chamber.

Length 0.75 mm.; breadth 0.40 mm.; thickness 0.06 mm.

The types of this species are from the Camp Colorado limestone member of the Pueblo formation of the Cisco, about 1½ miles northeast of Camp Colorado, Coleman County, Texas.

This is an unusually broad flattened form with the coiled portion making up a large part of the test.

Genus TEXTULARIA Defrance, 1824

Genoholotype, *Textularia sagittula* Defrance

Textularia Defrance, 1824, Dict. Sci. Nat., vol. 32., p. 177; H. B. Brady, 1884, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 356; Chapman, 1902, The Foraminifera, p. 165; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 114.
Textilaria Ehrenberg, 1839, Abhandl. Kais. Akad. Wiss. Berlin, p. 135.
Plecanium Reuss, 1861 (1862), Sitz. Akad. Wiss. Wien, vol. 44, p. 383.
Grammostomum (part) of authors.
Palaeotextularia Schubert, 1920, Pal. Zeitschr., vol. 3, p. 183.

Test free, elongate, tapering, usually compressed with the zigzag line between the chambers on the middle of the flattened sides, early chambers in the microspheric form usually planispirally coiled, later biserial, chambers simple, not labyrinthic; wall arenaceous, the relative amount of cement varying much; aperture, typically an arched slit at the inner margin of the chamber, occasionally in the apertural face.

Cambrian to Recent.

TEXTULARIA EXIMIA Eichwald

Pl. 4, figs. 9–11

Textilaria eximia Eichwald, 1860, Lethaea Rossica, vol. 1, p. 355, pl. 22, figs. 19 *a–d.*
Textularia eximia H. B. Brady, 1876, Pal. Soc. Mon. 30, p. 132, pl. 10, figs. 27–29; Lange, 1925, Verh. Geol.-Mijn. Gen. Ned. Kol., Geol. Ser., vol. 7, p. 237, pl. 2, fig. 36.

Test elongate, slender, tapering, only slightly compressed; chambers numerous, distinct, depressed, only slightly oblique; wall rather coarsely arenaceous, surface roughened, but very firmly cemented; aperture, an arched opening at the inner margin of the final chamber.

Length 0.75 mm.; breadth 0.25 mm.; thickness 0.18 mm.

Brady records this species from the Carboniferous of England and the Carboniferous of Russia. Our specimens in the Cisco agree well with the excellent figures given by

Brady, which are much more satisfactory than the originals. The specimens are from the Harpersville formation, found in sandy shale of the New Castle coal, Hardy Coal Mine, New Castle, Texas, and from the South Bend shale member of the Graham formation, 2 feet 6 inches below the Gunsight limestone on Salt Creek west of Graham, Young County, Texas.

TEXTULARIA GRAHAMENSIS Cushman and Waters

Pl. 12, figs. 1 *a*, *b*

Textularia grahamensis Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 151, pl. 27, figs. 3 *a*, *b*.
Palaeotextularia grahamensis Galloway and Ryniker, 1930, Oklahoma Geol. Surv., Circular 21, p. 21, pl. 4, figs. 13, 14.

Test slightly compressed in the young, rapidly thickening in the adult, tapering strongly in both front and side views, periphery rounded; chambers numerous, in the young with the width nearly double the height but becoming relatively higher in the adult; sutures horizontal, distinct, depressed strongly in the later portion; wall coarsely arenaceous; aperture large and rounded at the base of the inner margin of the chamber.

Length of holotype 1.25 mm.; breadth 0.65 mm.; thickness 0.50 mm.

The types of this species are from the Gunsight limestone member of the Graham formation of the Cisco on Salt Creek west of Graham, Young County, Texas.

This is a large stout species with the early chambers in the microspheric form showing a planispiral arrangement.

Genus BIGENERINA d'Orbigny, 1826

Genotype, by designation, *Bigenerina nodosaria* d'Orbigny

Bigenerina d'Orbigny, 1926, Ann. Sci. Nat., vol. 7, p. 261; H. B. Brady, 1884, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 368; Chapman, 1902, The Foraminifera, p. 168; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 118.
Gemmulina d'Orbigny, 1926, Ann. Sci. Nat., vol. 7, p. 262.

Test free, the early chambers biserial, later ones uniserial in a rectilinear series, not labyrinthic; wall usually thick,

arenaceous, usually coarse but often smoothly finished; aperture in the young biserial stage at the base of the inner margin of the chamber, in the adult uniserial stage terminal, rounded or oval, simple.

Carboniferous to Recent.

In the microspheric form the earliest chambers show more or less of the planispiral coiling, but this is not usually found in the megalospheric form.

BIGENERINA CISCOENSIS Cushman and Waters

Pl. 12, figs. 6 *a*, *b*

Bigenerina ciscoensis Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 63, pl. 8, figs. 5 *a*, *b*

Test small, elongate, the early portion compressed and tapering, the chambers biserial, later portion with the sides nearly parallel, of a few, 3–5, uniserial chambers in a rectilinear series; early chambers broad and low, increasing gradually in height as added, later uniserial chambers nearly as high as broad; sutures distinct, only slightly depressed; wall rather coarsely arenaceous but the angular grains neatly fitted and the surface fairly smooth, firmly cemented; aperture large for the size of the chamber, elliptical, terminal.

Length 0.45–0.50 mm.; breadth 0.12–0.15 mm.

The type of this species is from a sandy lignitic shale of the South Bend member of the Graham formation 2½ feet below the Gunsight limestone, on Salt Creek west of Graham, Young County, Texas.

Genus CLIMACAMMINA H. B. Brady, 1876

Genoholotype, *Climacammina antiqua* H. B. Brady

Climacammina H. B. Brady, 1876, Pal. Soc. Mon. 30, p. 67; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 120; Cushman and Waters, 1928, Journ. Pal., vol. 2, p. 124.

Test elongate, tapering in the early portion, later portion subcylindrical; chambers numerous, in the early stages biserial, textularian, later uniserial; wall of two distinct

layers, an inner, clear, perforate layer and an outer opaque, arenaceous layer; aperture in the biserial stage usually simple, at the inner margin of the chamber as in *Textularia*, later with a single opening becoming central, followed by a three- or four-aperture stage, then by a seven- or eight-aperture stage, consisting of a central opening surrounded by a series of triangular openings with the angle toward the central opening, and in the final stage often with numerous irregularly lobed or elongate openings in the apertural face of the chamber.

Carboniferous and Permian.

CLIMACAMMINA CYLINDRICA Cushman and Waters

Pl. 10, figs. 1–6

Climacammina cylindrica Cushman and Waters, 1928, Journ. Pal., vol. 2, p. 128, pl. 17, figs. 4, 9–13.

Test elongate, four or five times as long as wide, subcylindrical, periphery broadly rounded; early chambers in a biserial series, later ones uniserial, usually four in the adult, of uniform size, generally circular in section; sutures distinct, deeply depressed, especially in the uniserial portion; wall with a clear, perforate, inner layer and an outer, opaque, arenaceous layer; aperture in the earlier stages single, textularian, on the inner margin of the chamber, later with two or four irregularly angular openings, and in the adult with a central opening surrounded by a series of triangular openings, six or seven in number with the apices toward the central opening.

Length 2.0 mm.; breadth 0.60 mm.; thickness 0.60 mm.

The types of this species are from the Graham formation of the Cisco, on Salt Creek 1 mile west of Graham, Young County, Texas. Specimens also occurred in the Graham formation 10 miles northeast of Breckenridge, on the South Bend road, Stephens County, Texas.

Genus DECKERELLA Cushman and Waters, 1928

Genoholotype, *Deckerella clavata* Cushman and Waters

Deckerella Cushman and Waters, 1928, Journ. Pal., vol. 2, p. 128.

Test elongate, the early stages biserial, textularian, later chambers uniserial; wall with an inner, clear, perforate layer, and an outer, opaque, arenaceous layer; aperture in the early biserial chambers simple, textularian, at the inner edge of the chamber, later pushing into the apertural face, finally cutting off two distinct, elongate, elliptical apertures with a narrow partition between and this character continuing throughout the adult.

Pennsylvanian.

The development of the apertural features is very different in this genus from true *Climacammina.*

DECKERELLA LAHEEI Cushman and Waters

Pl. 11, figs. 1–14

Deckerella laheei Cushman and Waters, 1928, Journ. Pal., vol. 2, p. 130, pl. 18, figs. 1–14; pl. 19, figs. 3, 4, 6.

Test elongate, slender, cylindrical, early biserial chambers numerous, later uniserial ones up to four or five in number in the adult, of very uniform size, periphery broadly rounded; sutures distinct, depressed; wall consisting of an inner, clear, perforate layer and an exterior, arenaceous, opaque layer; apertures in the early, biserial chambers, simple, textularian, in the uniserial portion with two elongate, elliptical openings with a narrow partition between.

Length up to 2.25 mm.; maximum breadth 0.60 mm.; thickness 0.60 mm.

The types of this species are from the Graham formation of the Cisco from 10 miles northeast of Breckenridge, Stephens County. It occurs also in the Wayland shale member of the Graham formation 5 feet above the Gunsight limestone, on Salt Creek west of Graham, Young County, Texas.

Genus GEINITZINA Spandel, 1901

Genotype, by designation, *Textularia cuneiformis* Jones (not d'Orbigny)

Geinitzina Spandel, 1901, Festschr. nat. ges. Nürnberg, p. 15; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 119.
Geinitzella Spandel, 1898, Verlag.-Instit., "General Anzeiger," Nürnberg, p. 7.
Textularia (part) Jones (not Defrance) in Mantell, 1850, Quart. Journ. Geol. Soc., vol. 6, p. 330.

Test free, elongate, tapering, compressed, the early portion at least tapering, in some species reaching a maximum width early and the later portion with the sides parallel; chambers simple, uniserial or possibly biserial in the earliest stages in the microspheric form; wall finely arenaceous with much cement, usually with the exterior smoothly finished; aperture elongate, elliptical, or almost linear.

Carboniferous and Permian.

GEINITZINA CISCOENSIS Cushman and Waters

Pl. 4, figs. 12–15

Geinitzina ciscoensis Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 63, pl. 8, figs. 6 *a*, *b*.

Test cuneiform in front view, compressed, tapering gradually from the initial end, greatest breadth at the apertural end, periphery rounded; sutures indistinct, very slightly depressed; wall finely arenaceous, rather smoothly finished; aperture elongate, elliptical or even linear and more or less zigzag in shape.

Length 0.60 mm.; breadth 0.30 mm.; thickness 0.06 mm.

The types of this species are from the Pueblo formation of the upper Cisco, taken from the Camp Colorado limestone, about 1½ miles northeast of Camp Colorado, Coleman County, Texas. This is one of the earliest occurrences in the Texas Pennsylvanian of this genus, which is largely Permian in its range.

This species is primitive in its larger amount of arenaceous material, more evenly tapering form with the increase

in width continuing throughout most of the life instead of the later half having parallel sides as in the typical Permian forms.

Family MILIOLIDAE

Genus AGATHAMMINA Neumayr, 1887

Genotype, by designation, *Serpula pusilla* Geinitz

Agathammina Neumayr, 1887, Sitz. Akad. Wiss. Wien, vol. 95, pt. 1, p. 171; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 145.

Serpula (part) Geinitz (not Linné), 1846, Verst. Deutsch. Zechst. Roth., Heft 1, p. 6.

Trochammina (part) of authors.

Test tubular, undivided, winding about an elongate axis; wall imperforate, calcareous, with arenaceous material at the surface; aperture formed by the open end of the tubular chamber.

Carboniferous to Jurassic.

This is the most primitive of the genera of the Miliolidae and shows the development of the Miliolidae from *Glomospira*.

AGATHAMMINA PROTEA Cushman and Waters

Pl. 5, fig. 1

Agathammina protea Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 43, pl. 5, figs. 6 *a–c*.

Test nearly twice as long as wide, composed of a proloculum and long tubular second chamber coiled irregularly about an elongate axis, the plane of coiling changing so that only five or six coils are visible from the exterior; wall arenaceous with much cement, rather smoothly finished; aperture semicircular, at the end of the tubular chamber, usually a little below the end of the test.

Length 0.65 mm.; breadth 0.35 mm.; thickness 0.18 mm.

The types of this species are from the Admiral formation of the lower Permian of Coleman County, Texas. It is not surprising therefore to note the species from the upper portion of the Cisco where it occurs in the Dothan limestone

of the Moran formation at a depth of 490 feet, Farmers Ranch, Archer County, Texas. The Cisco specimens are possibly a little more arenaceous than the Permian ones, but otherwise they are very similar.

Family OPHTHALMIDIIDAE

Genus HEMIGORDIUS Schubert, 1908

Genoholotype, *Cornuspira schlumbergeri* Howchin

Hemigordius Schubert, 1908, Jahrb. k. k. Geol. Reichs., vol. 58, p. 381; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 161.

Cornuspira Howchin (not Schultze), 1895, Trans. Roy. Soc. South Australia, vol. 19, p. 195.

Test in the early coils at least of the microspheric form not entirely planispiral, later ones planispiral and usually completely involute but the test not definitely umbonate; wall calcareous, imperforate, often somewhat laminated. Carboniferous.

This represents the development of the planispiral growth of the primitive Ophthalmidiidae from such forms as *Glomospira* which in *G. simplex* Harlton gradually assume a calcareous, imperforate test. The forms with a large megalospheric proloculum may lack the early coils in changing planes and become planispiral from the start, but they show by their other characters their relationships.

HEMIGORDIUS HARLTONI Cushman and Waters

Pl. 5, figs. 2, 3

Hemigordius harltoni Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., Vol. 4, p. 43, pl. 5, figs. 8, 9.

Test compressed, circular in outline in side view, with the early stages coiled in varying planes, the later ones becoming planispiral, a proloculum and second chamber consisting of an elongate undivided tube, the middle portion of the test on either side covered with a secondary growth of material largely concealing the structure; wall calcareous, imperforate, smooth; aperture, a rounded opening formed by the open end of the tubular chamber.

Diameter of full grown specimens up to 1 mm.

This species was originally described from the Graham formation of the Cisco, 3.2 miles south of Jacksboro, Jack County, Texas.

This is a striking species keeping its characters very clearly. The megalospheric specimens are thicker in the middle than the microspheric ones. As the surface layers are very clear and translucent, it is possible to see the spiral suture through the thin covering for several coils near the periphery.

Genus CORNUSPIRA Schultze, 1854

Genotype, by designation, *Cornuspira planorbis* Schultze

Cornuspira Schultze, 1854, Organismus Polythal., p. 40; H. B. Brady, 1884, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 198; Chapman, 1902, The Foraminifera, p. 99; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 160.

Orbis (part) Philippi, 1844, Enum. Moll. Siciliae, vol. 2, p. 147.

Operculina (part) Czjzek, 1848, Haidinger's Nat. Abhandl., vol. 2, p. 146.

Spirillina (part) Williamson, 1858, Rec. Foram. Great Britain, p. 91.

Test consisting of a proloculum followed by a long planispirally coiled second chamber, rounded or complanate; wall calcareous, imperforate; aperture formed by the open end of the chamber, sometimes constricted and with a thickened lip.

Carboniferous to Recent.

CORNUSPIRA THOMPSONI Cushman and Waters

Pl. 5, fig. 4, 5

Cornuspira thompsoni Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 44, pl. 5, figs. 10 *a–c*.

Test small, planispiral throughout, much compressed, periphery acute and slightly keeled, one side somewhat flattened, other side slightly convex, consisting of a proloculum and elongate, compressed, tubular, second chamber; wall smooth, calcareous, imperforate; aperture formed by the open end of the tubular chamber.

Diameter 0.35 mm.

This species occurs in the Dothan limestone of the Moran formation of the Cisco in a core at 460 feet, Farmers Ranch, Archer County, Texas.

Genus APTERRINELLA Cushman and Waters, 1928

Genoholotype, *Tolypammina grahamensis* Harlton

Apterrinella Cushman and Waters, 1928, Contrib. Cushman. Lab. Foram. Res., vol. 4, p. 64.

Test attached, consisting of a proloculum and tubular second chamber with the early portion coiled about the proloculum, then uncoiling and wandering about over the surface to which it is attached; wall calcareous, imperforate; aperture semicircular, formed by the open end of the tubular chamber.

Pennsylvanian.

This is a primitive attached genus derived from such genera as *Hemigordius* or *Cornuspira*, becoming attached, and then wandering about over the surface. The test especially in the young where the wall is thin has the characteristic bluish-white appearance so common in this family.

APTERRINELLA GRAHAMENSIS (Harlton)

Pl. 5, figs. 6–9

Tolypammina grahamensis Harlton, 1928, Journ. Pal., vol. 1, No. 4, p. 305, pl. 52, fig. 1.

Apterrinella grahamensis Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 68, pl. 9, figs. 1–4.

Test attached to mollusc shells or other objects, consisting of a slightly compressed subspherical proloculum and tubular second chamber, the proloculum smooth and the early part of the tubular chamber in the microspheric form, later the surface strongly and irregularly reticulate, the sides of the tubular chamber spreading out over the surface of attachment in a thin flange, in the megalospheric form the large proloculum smooth but the reticulation of the wall beginning almost immediately after the proloculum; wall calcareous, imperforate, bluish-white in the thinner, early

stages; aperture semicircular, at the open end of the tubular chamber.

Length of adult specimens 10 millimeters or more.

The types of this species came from the Graham formation of the Cisco, "at cut in Rock Island R. R. at Perrin road crossway, 3 miles southeast of Jacksboro, Jack County, Texas." We have examined the holotype in the collection of the U. S. National Museum and find that the species is the same as the one we have so abundantly from the Dothan limestone of the upper Cisco at Farmers Ranch, Archer County, Texas, where it often nearly covers shells of *Myalina*.

The acceleration of development is very different in the two forms. In the microspheric form the peculiar coarsely reticulate pattern of the surface is not taken on until the smooth tubular test has persisted for some time. In the megalospheric forms with a very large proloculum, the reticulate surface is formed almost at once after the proloculum is formed.

Genus ORTHOVERTELLA Cushman and Waters, 1928

Genoholotype, *Orthovertella protea* Cushman and Waters

Orthovertella Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 45.

Test with the early coils in constantly changing planes, but close coiled, the later portion becoming uncoiled and more or less straight, consisting of a proloculum and tubular undivided second chamber; wall calcareous, imperforate; aperture formed by the open end of the tubular second chamber.

Pennsylvanian and Permian.

This genus comes from a *Glomospira*-like development, and shows well the development of the simpler types of the Ophthalmidiidae from the more primitive arenaceous Ammodiscidae.

ORTHOVERTELLA PROTEA Cushman and Waters

Pl. 5, figs. 10–13

Orthovertella protea Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 45, pl. 6, figs. 3, 4.

Test small, consisting of a close coiled young, the coils in constantly changing planes and the later portion becoming uncoiled and nearly straight, consisting of a proloculum and tubular, undivided, second chamber of nearly even diameter; wall smooth, calcareous, imperforate; sutures well marked; aperture formed by the open end of the tubular chamber, not constricted, without a tooth.

Length 0.40 mm.; diameter 0.20 mm.

The types of this species came from the Dothan limestone of the Moran formation of the Cisco, from drill core at 460 feet, Farmers Ranch, Archer County, Texas. It occurs rather widely distributed in the Cisco.

Genus CALCITORNELLA Cushman and Waters, 1928

Genoholotype, *Calcitornella elongata* Cushman and Waters

Calcitornella Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 45.

Test attached, consisting of a proloculum and long tubular, second chamber, the latter at first coiled, usually nearly planispiral in the early stages thence in a series of long bends back and forth upon itself, either elongate or forming an irregular coil; wall calcareous, imperforate; aperture formed by the open end of the tubular second chamber.

This is a form developed from a *Cornuspira* or *Hemigordius* type which has become attached, and in making broad swings back and forth has developed a peculiar structure which is seen in other related structures in the next two genera. Such forms have apparently not persisted beyond the Paleozoic and are to be regarded as specialized attached genera.

CALCITORNELLA ELONGATA Cushman and Waters

Pl. 5, figs. 14, 15; Pl. 6, figs. 1 *a*, *b*

Calcitornella elongata Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 47, pl. 6, fig. 5.

Test elongate, attached, consisting of a close coiled early portion and an elongate later growth, the tubular chamber bending back and forth on itself along a nearly straight axis, attached side conforming to the surface to which it is attached, outer surface convex and the structure obscured; sutures very distinct on the attached side; wall calcareous, imperforate, more or less roughened and irregular on the outer surface; aperture formed by the open end of the tubular chamber.

Length 1.25 mm.

The types of this species are from the South Bend shale of the Graham formation of the Cisco, 6 inches below the Gunsight limestone, on Salt Creek west of Graham, Young County, Texas. It is also common in the Dothan limestone of the Moran formation of the Cisco, from a core at a depth of 460 feet, Farmers Ranch, Archer County, Texas.

The somewhat zigzag along the axis with the elongate test will distinguish this species from the following.

CALCITORNELLA HEATHI Cushman and Waters

Pl. 6, figs. 2, 3

Calcitornella heathi Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 48, pl. 6, figs. 8 *a*, *b*.

Test attached, compressed and scale-like, ventral side conforming to the surface to which it is attached, dorsal side irregular and the earlier coils obscured, consisting of a proloculum and elongate tubular second chamber, the early portions definitely spiral, later ones bending back and forth about the periphery of the earlier ones, often partially involute; sutures distinct on the ventral side; wall calcareous, imperforate, the exterior roughened; aperture formed by the open end of the tubular chamber.

Diameter of type specimen 0.60 mm.

The types of this species are from the Wayland shale of the Graham formation of the Cisco, 5 feet above the Gunsight limestone, on Salt Creek west of Graham, Young County, Texas, where it occurs in considerable numbers. This is an attached form and the involute character of the upper side obscures the structure. Specimens were only lightly attached however as many of them are found free and from the under side the structure is clearly visible.

Genus CALCIVERTELLA Cushman and Waters, 1928

Genoholotype, *Calcivertella adherens* Cushman and Waters

Calcivertella Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 48.

Test attached with the earlier stages irregularly coiled, later in a definite zigzag series, the tubular second chamber bending back and forth but with the sides of the resulting test very slightly tapering, the last portion largely losing the coiled portion and becoming somewhat straight; wall calcareous, imperforate; aperture rounded, formed by the open end of the tubular chamber.

This genus is a parallelism with *Ammovertella* in the arenaceous group.

CALCIVERTELLA ADHERENS Cushman and Waters

Pl. 6, fig. 4

Calcivertella adherens Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 48, pl. 6, fig. 7.

Test attached, the early portion irregularly coiled, later portion in zigzag convolutions, the sides of the resulting test nearly parallel, the diameter of the tubular chamber increasing gradually, the last-formed portion tending to become straight; wall fairly smooth, calcareous, imperforate; aperture rounded, formed by the open end of the tubular chamber.

Length of type specimen 1 mm.; diameter of tube near aperture 0.18 mm.

The type of this species is from the Bunger limestone member of the Graham formation of the Cisco, 3.2 miles northeast of South Bend, Young County, Texas.

From the present records this seems to be a rather rare species.

Genus PLUMMERINELLA Cushman and Waters, 1928

Genoholotype, *Plummerinella complexa* Cushman and Waters

Plummerinella Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 49.

Test attached, compressed, consisting of a proloculum and long, undivided, tubular, second chamber, earliest portion coiled in a more or less planispiral manner, later in regular convolutions bending back and forth, but the whole closely coiling upon itself in a regular manner, in the last chambers becoming irregular; sutures clear on the attached side but structure obscured from the upper surface which is more or less involute; wall roughened on the dorsal side, calcareous, imperforate; aperture in the earliest stages formed by the open end of the tubular chamber, in the adults somewhat obscure, probably at one side representing the opening of the final convolution of the tubular chamber.

This structure is complex for a tubular chamber without true divisions.

PLUMMERINELLA COMPLEXA Cushman and Waters

Pl. 6, fig. 5

Plummerinella complexa Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 49, pl. 6, fig. 6.

This species with the characters of the genus is a peculiar one in the complexity of the structure that has been developed from a simple tubular chamber, the early planispiral stage, followed by several regular coils but the tubular chamber bending regularly back and forth and the last-formed portion tending to spread out over the attached surface.

Longest diameter 0.80 mm.

The types of this species are from the Wayland shale member of the Graham formation of the Cisco, 5 feet above the Gunsight limestone on Salt Creek west of Graham, Young County, Texas.

The attached specimens give little hint of their true structure from the upper side. Many specimens are detached and the ventral side shows the full characters.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1860

Genotype, by designation, *Nautilus inflatus* Montagu

Trochammina Parker and Jones, 1860, Quart. Journ. Geol. Soc., vol. 16, p. 304; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 171.

Nautilus (part) Montagu (not Linné), 1808, Test Brit., Suppl., p. 81.

Rotalina (part) Williamson (not d'Orbigny), 1858, Rec. Foram. Great Britain, p. 56.

Lituola (part) Parker and Jones (not Lamarck), 1865, Philos. Trans., vol. 155, p. 407.

Haplophragmium (part) Siddall (not Reuss), 1879, Cat. British Rec. Foram, p. 4.

Ammoglobigerina Eimer and Fickert, 1899, Zeitschr. Wiss. Zool., vol. 65, p. 104.

Tritaxis Schubert, 1920, Pal. Zeitschr., vol. 3, p. 180.

Test free or adherent, spiral, trochoid, all chambers visible from the dorsal side, only those of the last-formed coil from the ventral; wall arenaceous; aperture, an arched slit on the inner margin of the ventral side of the chamber.

Carboniferous to Recent.

As used by some of the earlier authors, this genus contained various species now placed in other genera. The genus as here restricted comprises only those arenaceous forms that are truly trochoid in the arrangement of the chambers.

TROCHAMMINA GRAHAMENSIS Cushman and Waters, n. sp.

Pl. 6, figs. 8 *a–c*

Test with the chambers in a fairly high trochoid spire usually three chambers making up a whorl; periphery of

last whorl broadly rounded; chambers inflated, regularly increasing in size as added; sutures depressed; wall coarsely arenaceous, rather roughly finished on the exterior, firmly cemented; aperture, a narrow slit at the inner edge of the ventral side of the last-formed chamber.

Diameter 0.50 mm.; height 0.45 mm.

Holotype (Cushman Coll. No. 9163) from the South Bend shale member of the Graham formation of the Cisco, 2 feet 6 inches below the Gunsight limestone on Salt Creek west of Graham, Young County, Texas.

This is a stouter, higher species than the others of the Cisco and has normally three chambers making up a whorl.

TROCHAMMINA ARENOSA Cushman and Waters

Pl. 6, fig. 6, 7

Trochammina arenosa Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 152, pl. 27, figs. 4 *a–c*.

Test trochoid, much compressed, early chambers less compressed, later ones much compressed and spread out, four chambers in a whorl and three to four whorls in the test; sutures on the dorsal side slightly curved, on the ventral side nearly radial; wall rather coarsely arenaceous; aperture ventral, on the inner margin of the chamber.

Diameter of holotype 0.65 mm.; thickness 0.18 mm.

The types of this species are from the Brad formation of the Canyon group, 35 feet below the Ranger limestone, 54 miles southwest of Brownwood, Brown County, Texas. The specimens at the type locality are much compressed in later development, but this may be due in some measure to later compression. In the Cisco very similar forms occur in abundance at various places in the section. Pl. 6, fig. 7 is of a specimen from the South Bend shale of the Graham formation of the Cisco, 2 feet 6 inches below the Gunsight limestone on Salt Creek west of Graham, Young County, Texas. Pl. 6, fig. 6 is of a specimen from the shale below the Bunger limestone, about 14.7 miles north of Ranger on the Caddo road, Stephens County, Texas. We also have

specimens from the Harpersville formation of the Cisco, below the Saddle Creek limestone, 6 miles northwest of Breckenridge, Stephens County, Texas.

Genus GLOBIVALVULINA Schubert, 1920

Genoholotype, *Valvulina bulloides* H. B. Brady

Globivalvulina Schumert, 1920, Pal. Zeitschr., vol. 3, p. 153; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 171.
Valvulina (part) H. B. Brady (not d'Orbigny), 1876, Pal. Soc. Mon. 30, p. 89.

Test trochoid, subglobular or plano-convex, the ventral side flattened, dorsal side strongly convex; periphery rounded; chambers inflated, few; wall finely arenaceous with much cement, the main wall perforate, occasionally appearing with a thin outer layer; aperture low, arched, at the umbilical margin of the last-formed chamber.

Pennsylvanian and Permian.

GLOBIVALVULINA BISERIALIS Cushman and Waters

Pl. 8, figs. 1–5

Globivalvulina biserialis Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 64, pl. 8, figs. 7 *a–c*.

Test essentially biserial, the early portion covered by the later coils, whole test hemispherical, chambers added alternately on either side of an elongate axis, each strongly overlapping the preceding ones; chambers from the surface elongate, elliptical, due to the overlapping, sutures depressed, distinct; wall finely arenaceous, smoothly finished; aperture on the ventral side of the test in a broad depression with a distinct valvular projection of the chamber.

Diameter 0.50 mm.; height 0.22 mm.

The types of this species are from the Bunger limestone member of the Graham formation of the Cisco, 3.2 miles northeast of South Bend, Young County, Texas.

This species may be distinguished from the others of the genus by the peculiar "braided" appearance, all the chambers even the last-formed one, being on opposite sides of the nearly straight axis.

GLOBIVALVULINA OVATA Cushman and Waters

Pl. 8, figs. 6–11

Globivalvulina ovata Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 65, pl. 8, figs 8 *a–c.*

Test mainly biserial, the whole test ovate, chambers except the final one added alternately on either side of an elongate axis, each slightly overlapping the preceding ones; chambers from the surface broadly elliptical; sutures depressed, distinct; wall finely arenaceous, smoothly finished; aperture on the ventral side of the test in a very broad depression, with a slight valvular projection.

Diameter 0.50 mm.; height 0.30 mm.

The types of this species are from the South Bend shale member of the Graham formation of the Cisco, 1 foot below the Gunsight limestone on Salt Creek, 1 mile west of Graham, Young County, Texas.

This species may be distinguished from the preceding by the final chamber extending clear across the periphery breaking the biserial series, the broader exposure of the chambers on the surface being due to the slighter overlap.

GLOBIVALVULINA BULLOIDES (H. B. Brady)

Pl. 8, figs. 12, 13

Valvulina bulloides H. B. Brady, 1876, Pal. Soc. Mon. 30, p. 89, pl. 4, figs. 12–15.

Globivalvulina bulloides Schubert, 1920, Pal. Zeitschr., vol. 3, p. 153.

"Test free (or adherent?), oblong, rounded; composed of a few inflated segments, obscurely spiral in their arrangement. Superior surface, convex; inferior, flat or slightly concave, irregular, depressed at the umbilicus. Segments sub-globular, each succeeding one considerably larger than its predecessor. Diameter 1/80 to 1/50 inch (0.3 to 0.5 mm.)."

The above description is the one given by Brady for his species. Figure 12 may be taken as that of the type specimen, and the figure fits the material to which this specific name is assigned here. Brady's types were from "The

Fusulina-beds of the Upper Coal-measures of North America" (Southern Iowa).

It is evident that Pl. 5, fig. 13 of Brady is incorrectly drawn, as the spire is not in the center but low at one side. Some of Harlton's figures assigned to this genus are also incorrectly drawn in this respect, as a study of the type specimens shows.

G. bulloides has much more rounded chambers than the two preceding species, the overlap being much less. The figured specimen is from the Camp Colorado limestone of the Pueblo formation of the Cisco, about 1½ miles northeast of Camp Colorado, Coleman County, Texas.

GLOBIVALVULINA GAPTANKENSIS Harlton

Pl. 8, fig. 14

Globivalvulina gaptankensis Harlton, 1928, Journ. Pal., vol. 1, No. 4, p. 308, pl. 53, figs. 3 *a–c*.

"Test free, oblong, rounded, strongly inflated, subspherical, gradually increasing in size, six visible from the peripheral and dorsal side, only three from below; inferior surface flat, slightly depressed near the aperture; wall calcareous, smooth; aperture curved opening into the umbilicus. Diameter, 0.4–0.6 mm."

Harlton's types are from the Gaptank formation, 4 miles west of Marathon, along railroad cut near milepost 580, Pecos County, Texas.

The figured specimen is from the Gaptank formation at Wolf Camp, Brewster County, Texas.

Family PLACOPSILINIDAE

Genus STACHEIA H. B. Brady, 1876

Genotype, by designation, *Stacheia marginulinoides* H. B. Brady

Stacheia H. B. Brady, 1876, Pal. Soc. Mon. 30, p. 107; Chapman, 1902, The Foraminifera, p. 154; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 178.

Test attached, early chambers suggesting a spiral arrangement, later ones irregular, labyrinthic; wall arenaceous, with an outer imperforate layer; aperture simple, circular, often with a neck.

Carboniferous to Lias.

This genus has been used to include various attached forms that it was difficult to place elsewhere. The wall in the type species is arenaceous and the chambers labyrinthic.

STACHEIA PUPOIDES H. B. Brady

Pl. 7, figs. 1 *a*, *b*; Pl. 12, fig. 8

Stacheia pupoides H. B. Brady, 1876, Pal. Soc. Mon. 30, p. 115, pl. 8, figs. 17–27; Schwager, 1877, Boll. Com. Geol. Ital., vol. 8, p. 26, pl., fig. 94; Möller, 1879, Mém. Acad. Imp. Sci. St. Pétersbourg, ser. 7, vol. 27, No. 5, p. 78, pl. 2, fig. 6; Harlton, 1927, Journ. Pal., vol. 1, No. 1, p. 21, pl. 3, figs. 4 *a–h*.

"Test adherent, elongate, tapering, uniserial; composed of a line of irregular convex segments, either lying flat on the surface of a foreign body, or embracing it to a greater or less extent. Segments inflated; interior cancellated, or subdivided more or less regularly. Surface granular or nearly smooth."

The above is the original description of this species as given by Brady. Our Cisco specimens from shales just below the Gunsight limestone may be placed under this variable species. The chambers are obscure but are in a generally uniserial series although the axis may be very variable due to the shape of the supporting surface. The interior of the chambers in section seems to be subdivided. Where the species are attached to small objects such as the spines of *Productus*, they assume the more regular form figured by Brady.

Genus PLACOPSILINA d'Orbigny, 1850

Genoholotype, *Placopsilina cenomana* d'Orbigny

Placopsilina d'Orbigny 1850, Prodr. Pal., vol. 2, p. 96; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 176.

Test attached, composed of numerous chambers, early portion close coiled, later portions uncoiled and spreading out in a generally linear series, last chambers sometimes

free above the attachment; wall coarsely arenaceous; aperture rounded, at the end of the last-formed chamber.

Silurian to Recent.

There are specimens attached to shell fragments which seem to belong to this genus.

Various Paleozoic species have been assigned by different authors to the genus *Bullopora* Quënstëdt, 1856. The Jurassic species of Europe according to Dr. Paalzow who has examined the typical material and sent specimens to the senior author is the same as the cretaceous *Vitriwebbina* of Chapman. The test of the Paleozoic forms is different and they are here placed under *Placopsilina.*

PLACOPSILINA CISCOENSIS Cushman and Waters, n. sp.

Pl. 12, figs. 7, 9

Test attached, consisting of numerous hemispherical chambers, the earlier ones usually coiled, later ones uncoiled and spreading over the attached surface in a more or less irregular uniserial manner, chambers increasing gradually in size as added; wall apparently arenaceous; aperture indistinct in the specimens.

Holotype (Cushman Coll. No. 13150) from the Graham formation of the Cisco from 5 feet above the Gunsight limestone, Graham, Young County, Texas.

The specimens of this species are represented mostly by calcareous casts of the interior of the chambers, the original arenaceous wall being present only in a few specimens. The chambers appear therefore as smooth, evenly rounded bodies. The best preserved specimens show coiled chambers in the young.

Family ORBITOLINIDAE

Genus TETRATAXIS Ehrenberg, 1843

Genoholotype, *Tetrataxis conica* Ehrenberg

Tetrataxis Ehrenberg, 1843, Bericht. Preuss. Akad. Wiss. Berlin, p. 106; Cushman, 1928, Special Publ. No. 1, Cushman Lab. Foram. Res., p. 179.

Valvulina (part) H. B. Brady (not d'Orbigny), 1876, Pal. Soc. Mon. 30, p. 81.

Test conical, consisting of a proloculum and elongate second chamber, later broken up into elongate, crescentic

chambers which may be divided into chamberlets in some species; wall on the exterior arenaceous, the interior of clear material and perforate; aperture elongate, at the margin of the umbilical border of the chamber.

Carboniferous and Permian.

TETRATAXIS CONICA Ehrenberg

Pl. 7, figs. 2 *a*, *b*, 4, 5 *a*, *b*

Tetrataxis conica Ehrenberg, 1843, Bericht. Preuss. Akad. Wiss. Berlin, p. 106; 1854, Mikrogeologie, pl. 37, xi, figs. A–D, No. 12; Möller, 1879, Mém. Acad. Imp. Sci., St. Pétersbourg, ser. 7, vol. 27, No. 5, p. 71, pl. 2, figs. 3 *a–g;* Harlton, 1927, Journ. Pal., vol. 1, p. 22, pl. 4, figs. 5 *a–d.*

Test conical, a vertical section making nearly an equilateral triangle, chambers numerous, the earliest portion without divisions, later chambers assuming the four series characteristic of the genus; sutures very slightly depressed, rather indistinct; outer wall often rather coarsely arenaceous, inner wall clear and perforate.

Diameter 0.65 mm.; height 0.50 mm.

In some parts of the Graham formation of the Cisco this species is well developed, especially in the Bunger limestone, 3.2 miles northeast of South Bend, Young County, Texas, the locality from which the figured specimens came. The specimens here have a coarsely arenaceous exterior of lime fragments firmly cemented. In other places the arenaceous outer layer is made up of finer material and the resulting surface smoother.

TETRATAXIS CORONA Cushman and Waters

Pl. 7, figs 3, 8

Tetrataxis corona Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 65, pl. 8, figs. 10 *a*, *b*.

Test with the central portion high, rounded conical, the later portion spreading, in side view concave; chambers of the early portion less distinct than the later, spreading ones, early developing in four series; sutures distinct in later development, slightly depressed, less distinct in the early

portion; wall fairly smooth, the outer arenaceous layer more marked in the conical young.

Diameter 0.50 mm.; height 0.20 mm.

The types of this species are from the Wayland shale member of the Graham formation, 5 feet above the Gunsight limestone, on Salt Creek, 1 mile west of Graham, Young County, Texas. The species occurs as high in the Cisco as the Camp Colorado limestone of the Pueblo formation, 1½ miles northeast of Camp Colorado, Coleman County, Texas.

This is a very fine little species with the early portion in a rounded conical shape and the later chambers flaring. It does not attain a large size.

TETRATAXIS SCUTELLA Cushman and Waters

Pl. 7, figs. 6, 7, 9

Tetrataxis scutella Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 65, pl. 8, figs. 9 *a*, *b*.

Test low and scale-like, the central portion barely raised above the general almost flattened surface; chambers elongate and narrow arranged throughout the adult stage in series of four, distinct; sutures distinct, often sharply depressed; wall with a fine arenaceous exterior, smoothly finished.

Diameter 0.80 mm.; height 0.12 mm.

The types of this species are from the South Bend shale member of the Graham formation, 1 foot below the Gunsight limestone, on Salt Creek 1 mile west of Graham, Young County, Texas. It has a very much depressed spire and the chambers are very distinct. Whereas such species assume somewhat the form of *Polytaxis*, they do not depart from the character of having the chambers in series of four.

Genus POLYTAXIS Cushman and Waters, 1928

Genoholotype, *Polytaxis laheei* Cushman and Waters

Polytaxis Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 51.

Test in the early stages similar to *Tetrataxis*, the earliest stage coiled, followed by elongate chambers in series of four,

then in the adult, spreading, and many chambers making a series about the peripheral edge, ventral side concave, irregular; apertures several, elongate, on the ventral side.

This genus has developed from *Tetrataxis*, and represents a specialized structure.

POLYTAXIS MULTILOCULATA (Cushman and Waters)

Pl. 12, figs. 5 *a*, *b*

Tetrataxis multiloculata Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 153, pl. 27, fig. 6 *a*, *b*.
Polytaxis multiloculata Cushman and Waters, 1928, idem, vol. 4, p. 51.

Test much compressed, the early chambers forming a small low spire, later ones much spread out and toward the edge lobed and divided into numerous smaller chambers, sutures very distinct, slightly limbate; wall finely arenaceous, with a large proportion of cement; ventral side with the chambers only at the periphery, scale-like and overlapping.

Diameter of holotype 1.60 mm.

The type locality for this species is from the Breckenridge limestone of the Thrifty formation, 1 mile south of Breckenridge, Stephens County, Texas.

This is a very distinct species, and the chambers are very distinct especially those of the outer portion, which become more than four in number in a series.

Family NONIONIDAE

Genus GLYPHOSTOMELLA Cushman and Waters, 1928

Genoholotype, *Ammochilostoma (?) triloculina* Cushman and Waters

Glyphostomella Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 53.

Test involute, only the chambers of the last-formed coil visible from the exterior, earlier chambers not entirely bisymmetrically arranged, later ones more nearly so; chambers inflated, a few making up the whole of the exterior of the test, sub-globular, regularly increasing in size as added;

wall finely arenaceous with a large proportion of cement, smoothly finished, perforate; apertures in the early stages parallel to the margin of the chamber and suture, later developing at right angles to the base of the chamber, several on each chamber in the adult and occasionally irregular ones in the apertural face, the apertures connecting with the interior by a funnel-shaped structure.

Pennsylvanian.

GLYPHOSTOMELLA TRILOCULINA (Cushman and Waters)

Pl. 9, figs. 1–9

Ammochilostoma (?) triloculina Cushman and Waters, 1927, Contrib. Cushman Lab. Foram. Res., vol. 3, p. 152, pl. 27, figs. 5 *a*, *b*.
Glyphostomella triloculina Cushman and Waters, 1928, Contrib. Cushman Lab. Foram. Res., vol. 4, p. 54, pl. 6, figs. 11–13; pl. 7, fig. 1.

Test usually with three visible chambers in a planispiral coil; chambers sub-globular, increasing in size as added, sutures very distinct, slightly depressed; wall finely arenaceous, with a large proportion of cement, smoothly finished; aperture slit-like at the base of the chamber in the median line and in the adult apparently two supplementary long slit-like openings at the sides of the chamber.

Diameter of holotype 0.50 mm.; thickness 0.35 mm.

The type locality for this species is the South Bend shale member of the Graham formation, from 1 foot below the Gunsight limestone, on Salt Creek 1 mile west of Graham, Young County, Texas, where it is common and well developed.

FAMILY?

Genus TUBERITINA Galloway and Harlton, 1928

Genoholotype, *Tuberitina bulbacea* Galloway and Harlton

Tuberitina Galloway and Harlton, Journ. Pal., vol. 2, 1928, p. 346.

Test attached in life, probably to plants, by a basal disc from which rises a bulbous chamber; monothalmous or polythalmous; succeeding chambers are attached to the preceding chamber by a disc which is smoothly moulded on the

preceding chamber, so that the chambers appear to be connected by thick necks; the chambers may be attached to the top of the preceding ones, making a rectilinear or curvilinear series, or to the sides of the preceding ones, making irregular tests; the chambers increase in size as added, and are filled with clear or granular calcite; there are no foramina connecting the chambers; walls calcareous, thick, completely soluble in acid, very finely but obscurely perforate; surface with conspicuous puncta, each of which corresponds to a smaller perforation, or smooth when calcified; aperture absent. Length, up to 1.2 mm. Found in shales. Pennsylvanian of Oklahoma.

This genus assigned to the foraminifera has little to indicate its relationship to that group. Its structure and method of development are not those of typical foraminifera, and it should probably be assigned elsewhere.

The type species, "*Tuberitina bulbacea* Galloway and Harlton," occurs in the Cisco of Texas, and is here figured, Pl. IX, figs. 10–14.

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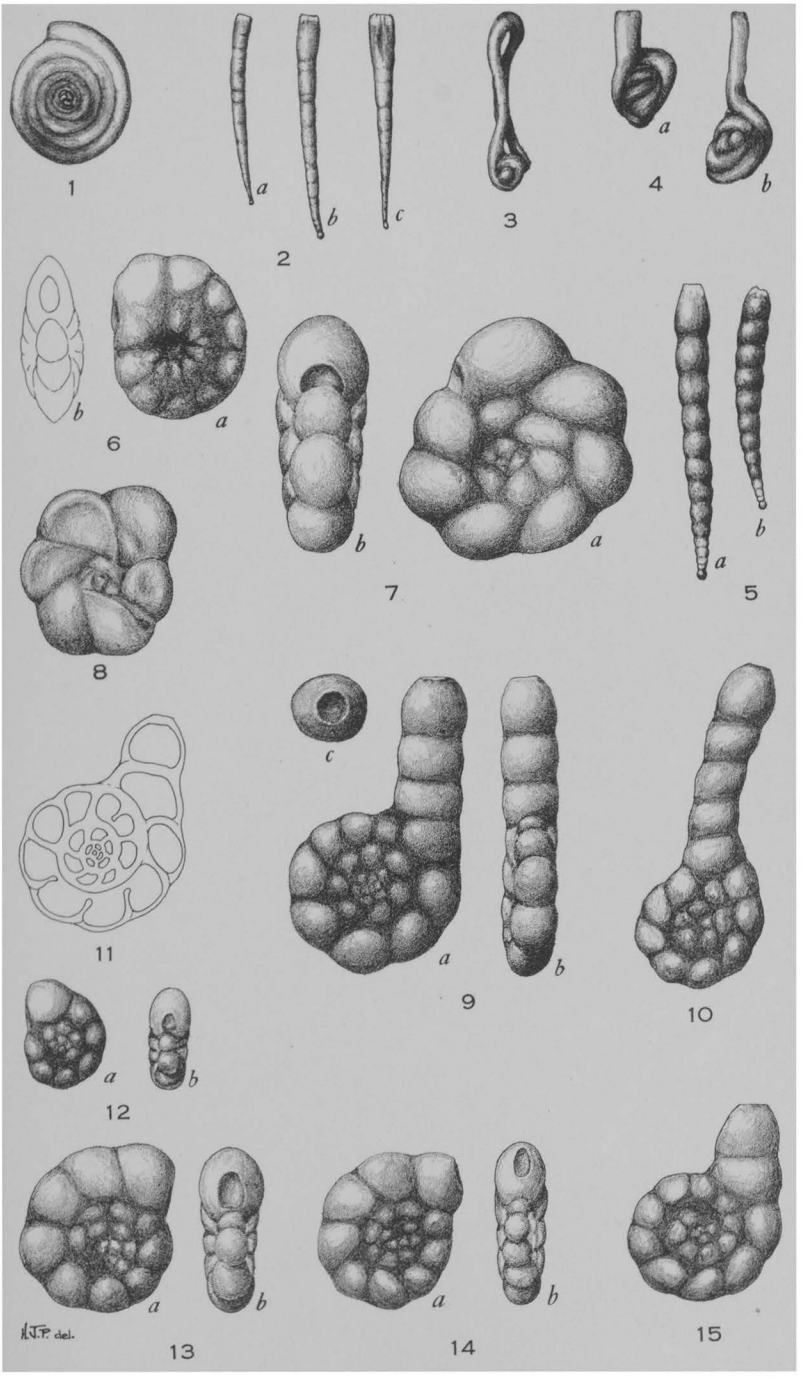
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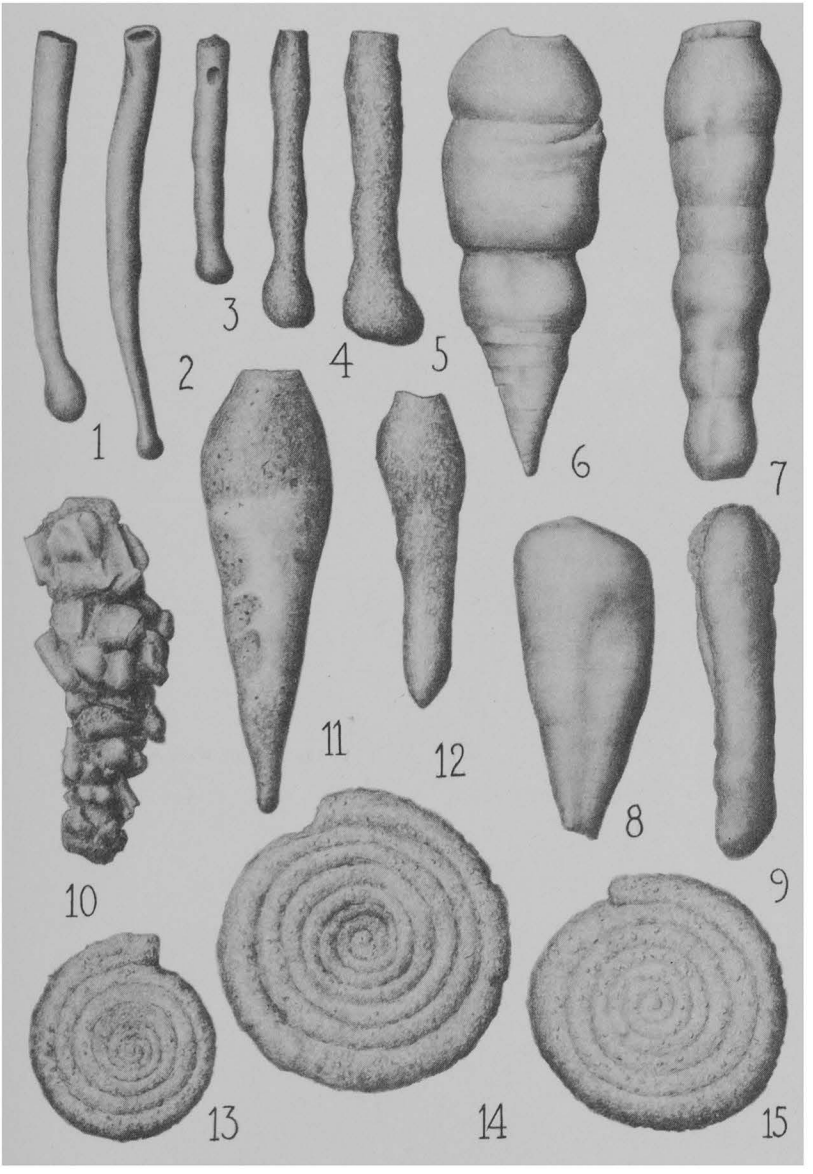
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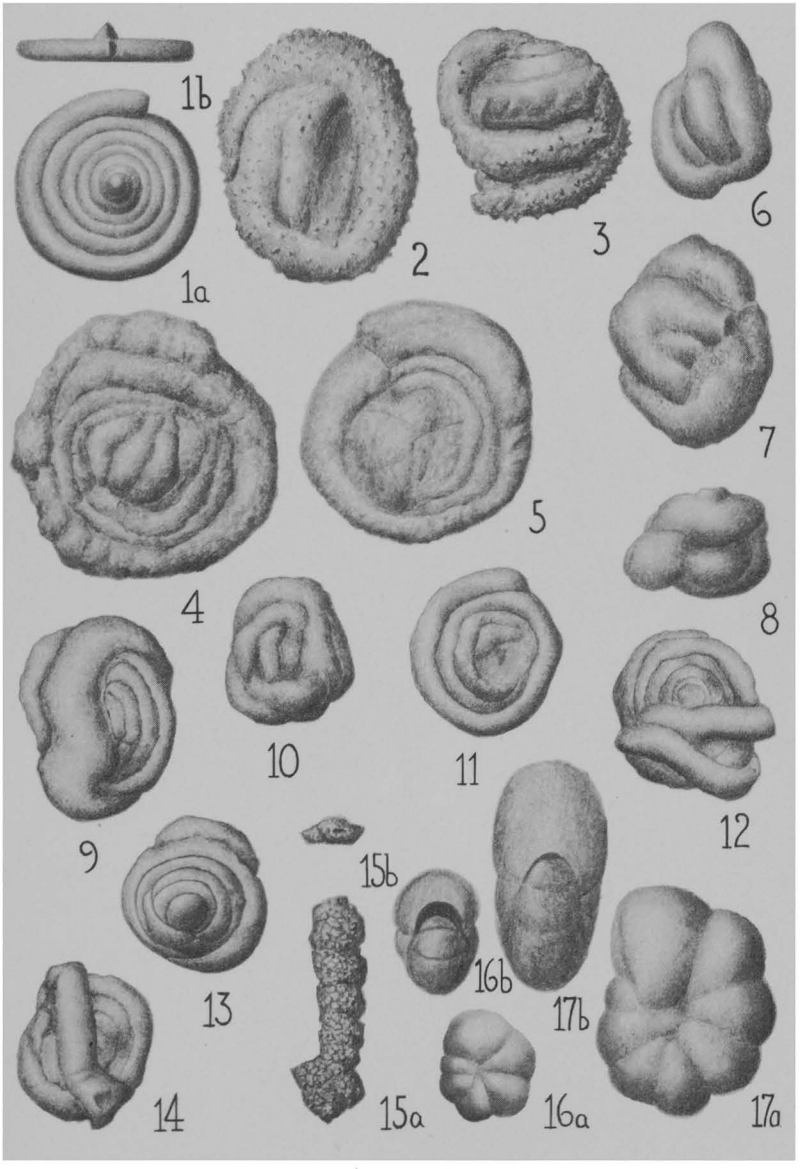
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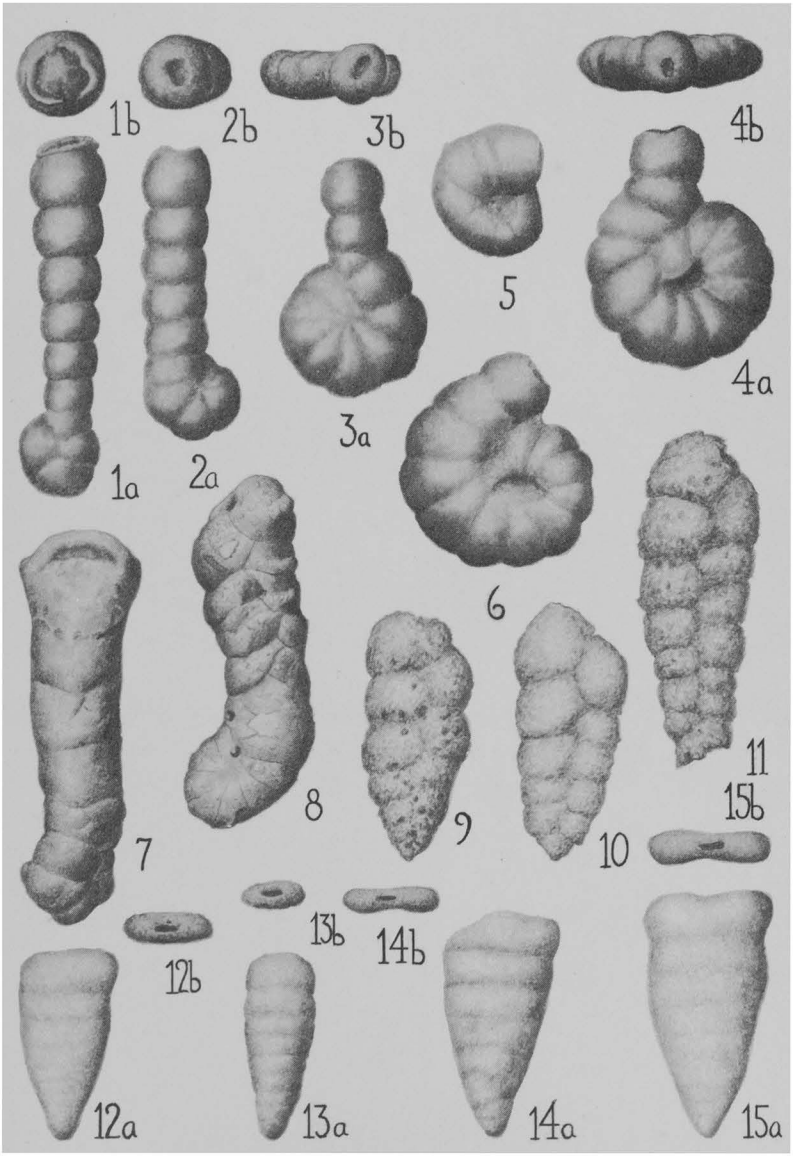
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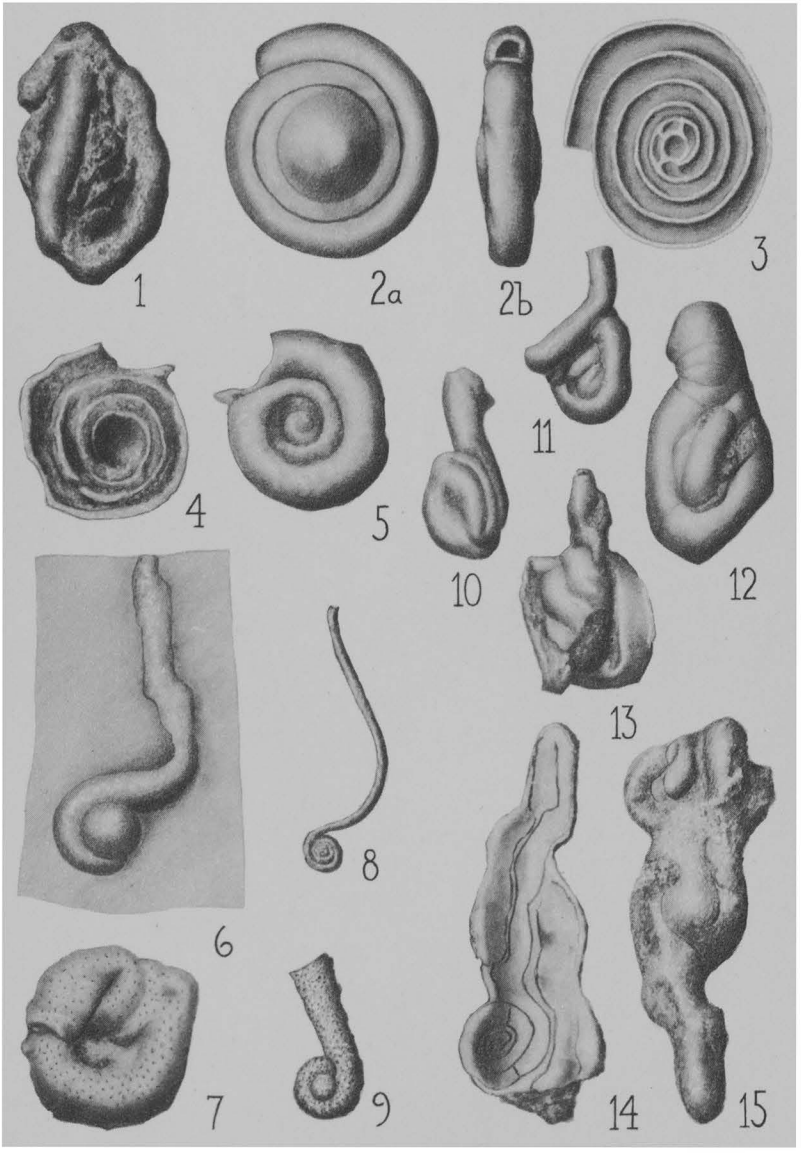
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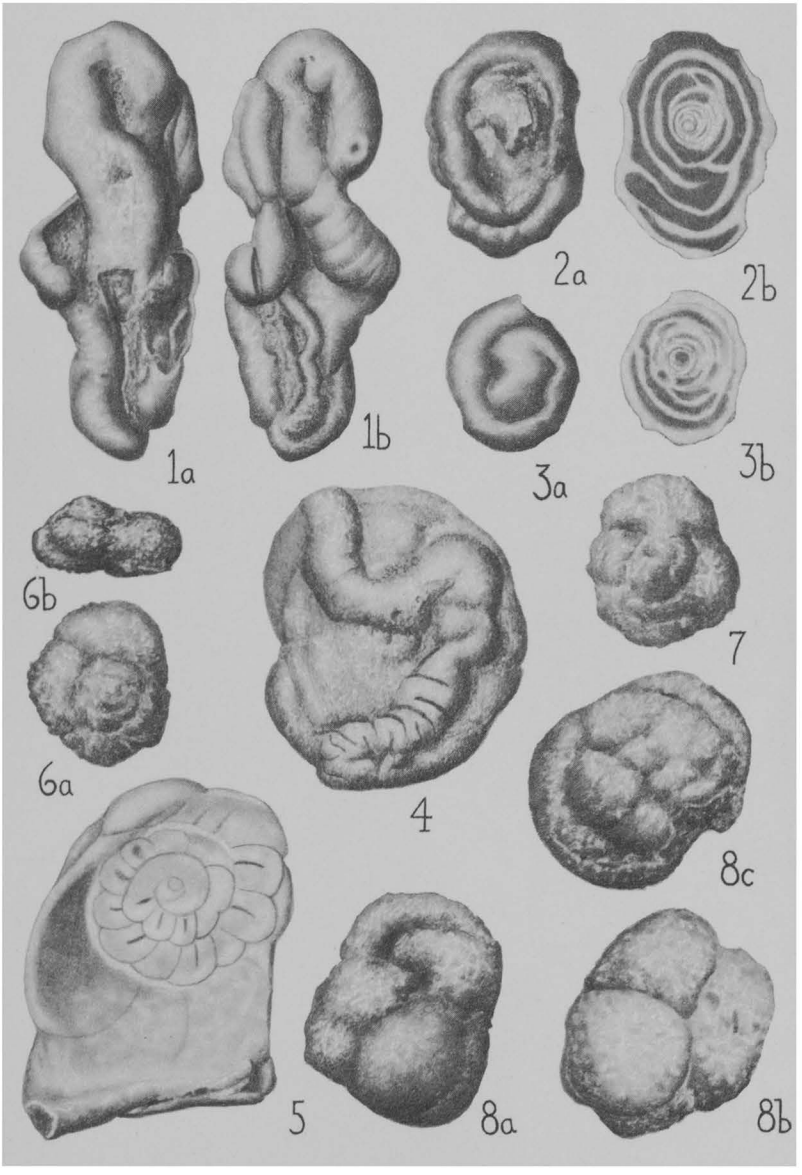
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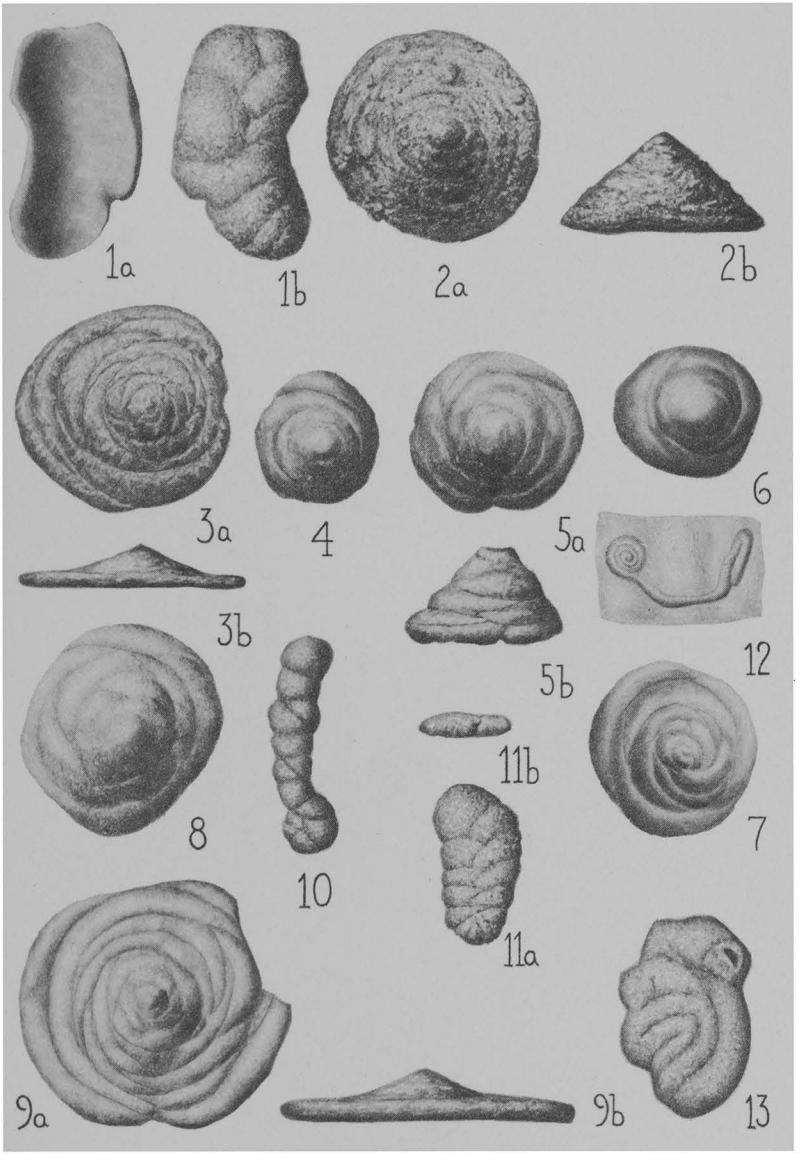
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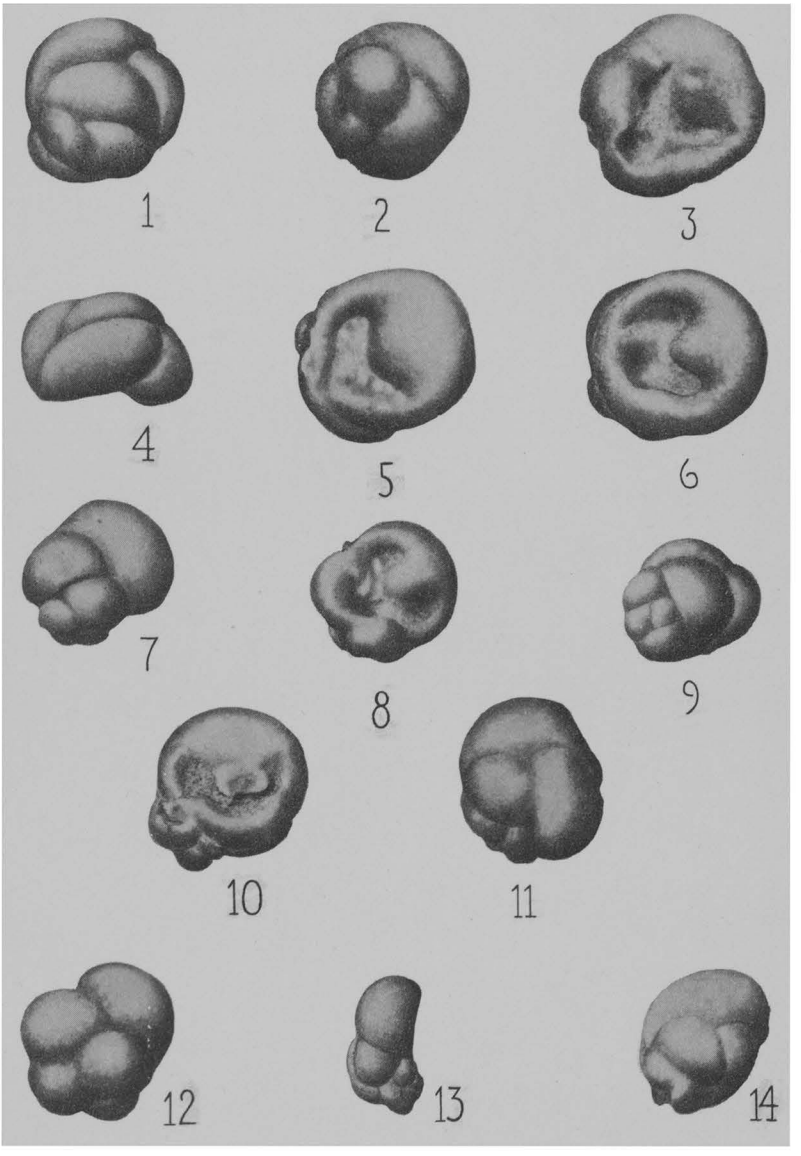
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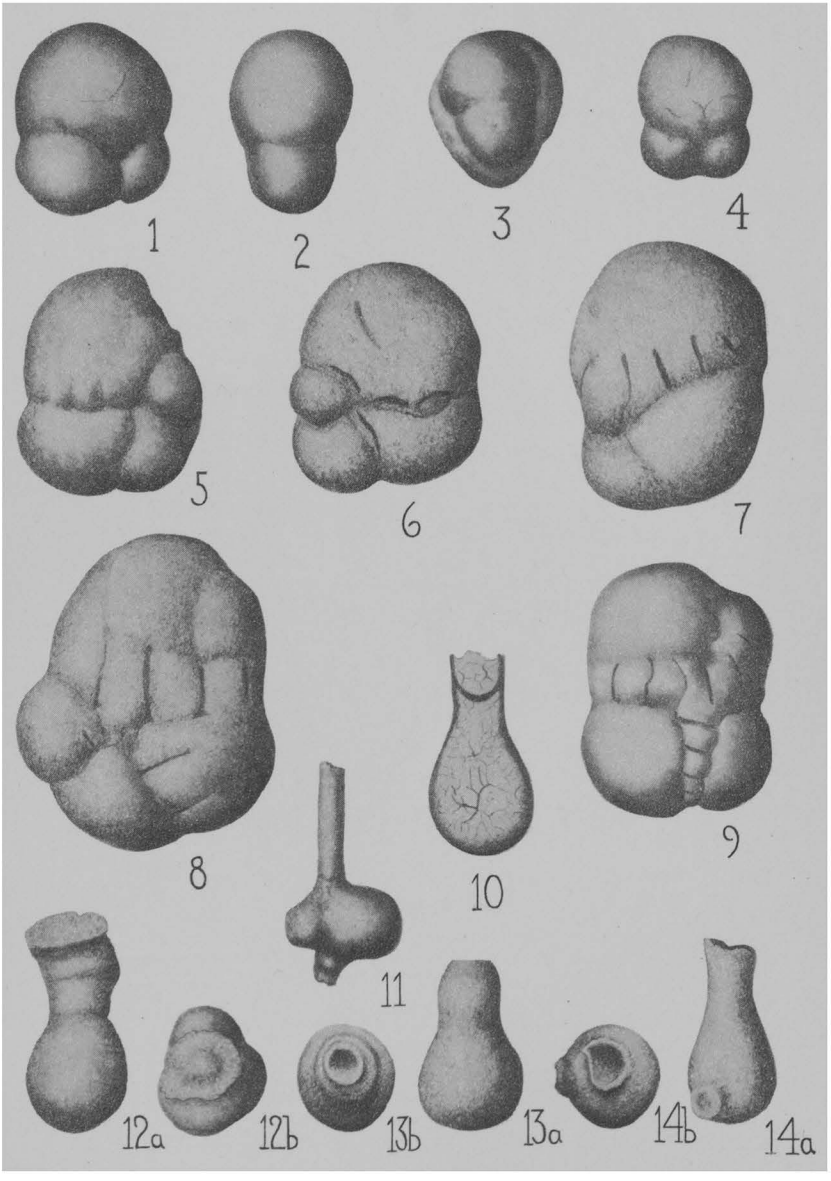
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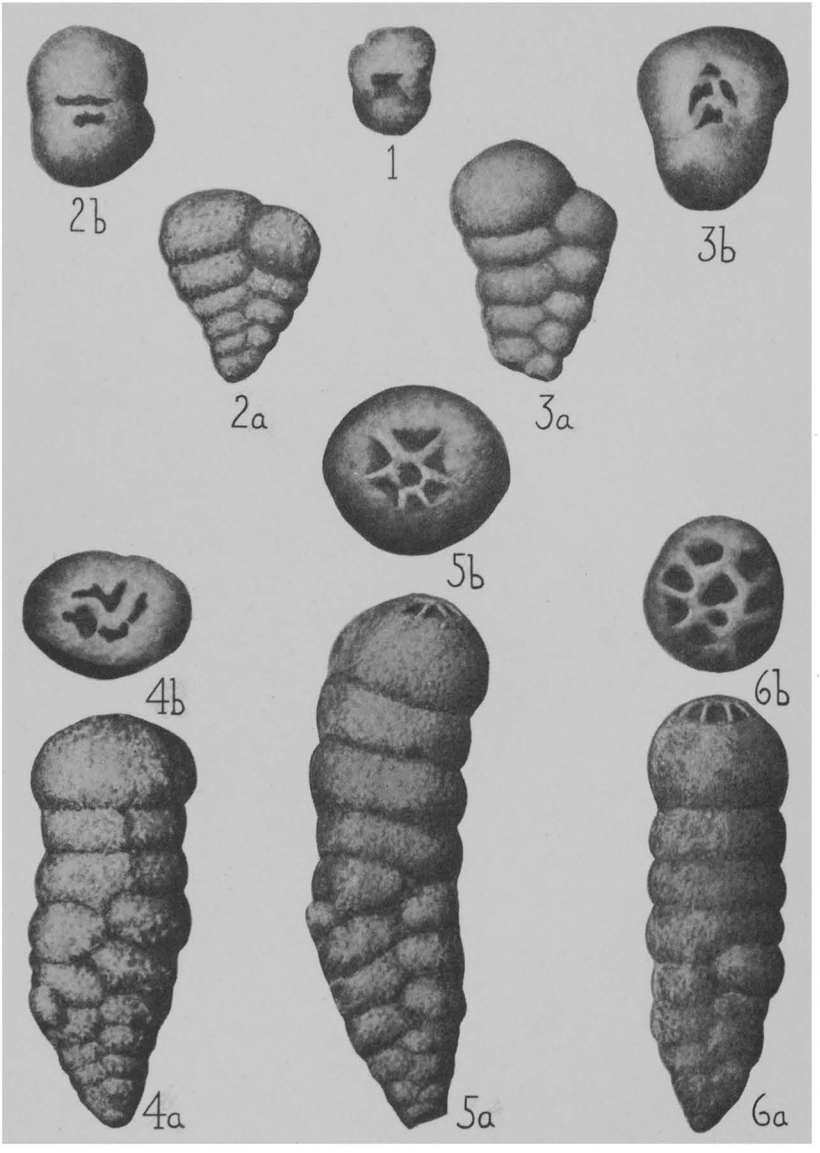
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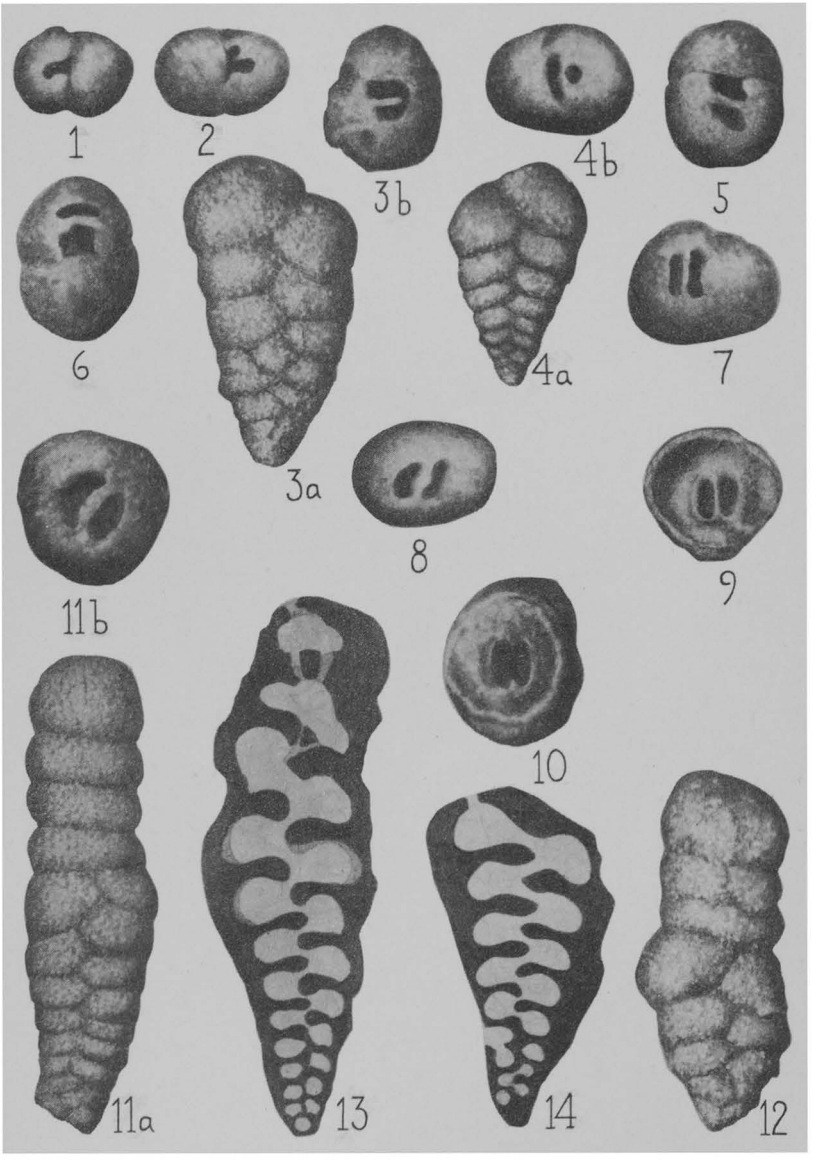
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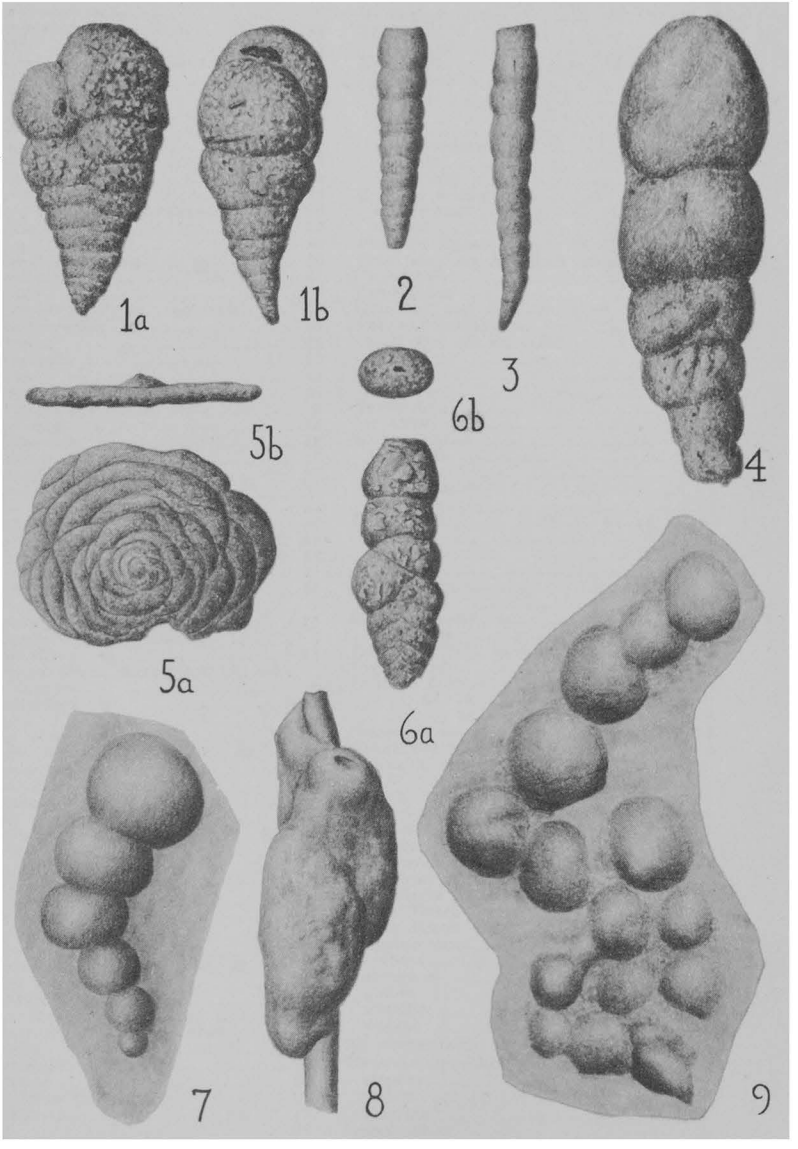
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